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Mr. Gregory Rudloff
United States Environmental Protection Agency (USEPA)
Region 5
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Chicago, IL 60604

January 31, 2020

Subject: Draft Corrective Measures Proposal for the Former Dow Hanging Rock Site, Ironton, OH EPA ID# OHR 000 157 727 and OHD 039 128 913

Dear Mr. Rudloff,

On behalf of The Dow Chemical Company, Jacobs, is submitting the above referenced report for your review.

Please contact me at (513) 673-2201 or Mr. Jerome Cibrik at (304) 747-7788 should you have any questions or comments.

Sincerely,

Marie W. Chiller

Marie W. Chiller, Jacobs
Site Manager

cc: Jerome Cibrik/The Dow Chemical Company

Former Dow Hanging Rock Plant, Ironton, Ohio

Corrective Measures Proposal

Draft

January 2020

The Dow Chemical Company

Former Dow Hanging Rock Plant, Ironton, Ohio

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Acronyms and Abbreviations

AmSty	American Styrenics
AOC	area of concern
AS	air sparging
bgs	below ground surface
CH2M	CH2M HILL Engineers, Inc.
CMP	Corrective Measures Proposal
COC	constituent of concern
Consent Order	Administrative Order on Consent
COPC	constituent of potential concern
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
Dow	The Dow Chemical Company
DPT	direct-push technology
Duke	Duke Energy
ELCR	excess lifetime cancer risk
ERH	electrical resistance heating
HI	hazard index
IC	institutional control
Jacobs	Jacobs Engineering Group Inc.
MCL	maximum contaminant level
ODNR	Ohio Department of Natural Resources
PCE	tetrachloroethene
Permit	RCRA Part B Permit
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFI	Resource Conservation and Recovery Act facility investigation
RSL	regional screening level
SHHRA	screening-level human health risk assessment
site	The Dow Chemical Company former Hanging Rock Plant in Ironton, Ohio
SLERA	screening-level ecological risk assessment
SVE	soil vapor extraction
SWMU	solid waste management unit
TCE	trichloroethene
TCH	thermal conduction heating
USEPA	U.S. Environmental Protection Agency
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound

1. Introduction, Purpose, and Objectives

This Corrective Measures Proposal (CMP) has been prepared for The Dow Chemical Company (Dow) former Hanging Rock Plant in Ironton, Ohio (site) to outline potential remedial alternatives addressing subsurface soil gas and groundwater impacts at the site. The CMP follows the next corrective action step required by the September 2016 Administrative Order on Consent (Consent Order) between Dow and the U.S. Environmental Protection Agency (USEPA 2016).

Dow has been performing Resource Conservation and Recovery Act facility investigations (RFIs) in phases at the site since 2011 to evaluate the nature and extent of constituents of concern (COCs) in surface and subsurface soil, groundwater, indoor and outdoor air, and soil gas. Human health and ecological risk assessments have been completed and updated during the RFI phases (CH2M HILL Engineers, Inc. [CH2M] 2014a, 2017a; Jacobs Engineering Group Inc. [Jacobs] 2019a). These investigations and risk assessment findings have progressively increased the knowledge of site conditions and aided in optimizing final corrective measure development.

This CMP presents the supporting information necessary for USEPA to approve the proposed corrective measures, develop a statement of basis for public comment, and issue a Final Decision for corrective action at the site. The corrective measures remedial action objectives (RAOs) for the site, which are discussed in Section 4, address the potential human health risks and associated COC exposure pathways.

2. Site Background

This section presents site background information including a site description, regulatory history, RFI findings, and a summary of site human health and environmental risks. RFI Phases 1, 2, and 3 investigation reports provide details about the site and serve as the principal reference documents for this section (CH2M 2014a, 2017a; Jacobs 2019a).

2.1 Site Description

The site is an approximately 750-acre parcel in south-central Ohio, approximately 4 miles northwest of Ironton, Ohio (Figure 2-1). The site consists of active operations in the north-central portions, farmland, and woods (Figure 2-2). The site is bordered to the north by U.S. Highway 52 and wooded upland hills, and on the east, west, and south by farmland, residences, and the Ohio River.

Dow began operating at the facility in 1957 manufacturing polymeric beads and foam (Styrofoam). Within the site boundary, American Styrenics (AmSty) operates a Styron plant, and Duke Energy (Duke) operates a power plant. The site boundary includes the entire property once owned by Dow, although only a portion contains developed land and active operations (Figure 2-3). Resource Conservation and Recovery Act (RCRA) corrective action is focused on the former Styrofoam and Styron manufacturing areas and associated solid waste management units (SWMUs) and areas of concern (AOCs), which are shown on Figure 2-4.

In 2017, Dow ceased operations and sold the property to AmSty, Duke, and the Lawrence Economic Development Corporation. Site buildings are used for industrial manufacturing operations, as well as warehouse and office space. Some buildings are currently vacant.

2.2 Geological and Hydrogeological Setting

Information on the subsurface geology across the site was obtained from the soil borings and monitoring wells that were installed during the RFIs as well as boring logs obtained from the Ohio Department of Natural Resources (ODNR). Cross-section A-A' was developed using the site monitoring wells and runs north to southeast across the site (Figure 2-5).

The unconsolidated soil described on the ODNR logs and observed onsite consists of surficial fill material, including silt, clay, asphalt, concrete, and sand, and was encountered from the ground surface to depths ranging from 0.5 to 2 feet below ground surface (bgs). Surficial fill is generally underlain by up to 10 feet of a fine-grained, low-permeability (sand, sandy clay, clay, silt, sandy silt, clayey silt, and silty clay) layer. The fine-grained unit appears to be thicker in the center of the site and contains sand to fine sand in the lower 5 to 10 feet of this unit. The lower 6 to 10 feet of silt and fine sand are saturated in the center of the site. This saturation is being held in place by capillary fringe since the fine-grained unit is underlain by up to 70 feet of a coarse-grained sand and gravel unit that extends down to the top of bedrock. This capillary water is likely immobile, except for some downward migration into the underlying coarse-grained unit when the hydraulic head in the silt and fine sand unit exceeds the capillary pressure of the soils (e.g., from infiltration of precipitation).

The fine-grained unit is believed to be Ohio River floodplain deposits. The sand and gravel layer beneath the fine-grained unit is likely alluvial deposits deposited by the Ohio River and colluvium formed when loose material rolled from the top of the moderate grade slope of the Ironton Plateau and built up at the bottom of a low-grade slope. The ODNR well logs describe bedrock as occurring between 75 and 80 feet bgs. Deep borings advanced onsite encountered bedrock between 79 and 83 feet bgs. The bedrock encountered in the three deep borings (MW-01, MW-05, and MW-07) was gray shale.

Groundwater levels were measured in January 2012 in the seven monitoring wells installed during the Phase 1 investigation and in February 2016 during the Phase 3 investigation. Groundwater generally occurs between 26 to 29 feet bgs. Based on these measurements, the sitewide shallow groundwater generally flows from northwest to southeast toward the Ohio River. Figure 2-6 shows the 2016 potentiometric surface.

2.3 Regulatory Overview

Table 2-1 provides a regulatory summary of RCRA activities conducted between 1980 and 2019. RCRA activities began under a Part A and Part B Permit for the active facility in the 1980s. On May 24, 2006, USEPA issued an RCRA Part B Permit (Permit) for the site under USEPA Identification Number OHO 039 128 913. The Permit contained requirements for the combustion of a hazardous waste in boiler and corrective action pertaining to 17 SWMUs and 5 AOCs.

On August 31, 2010, the Permit was modified to delete the boiler-related Permit conditions, remove Dow as an "operator" under the Permit to reflect the lack of any operator of a hazardous waste unit at the site, and clarify that Dow remained responsible for compliance with the corrective action requirements in the Permit. A second USEPA site Identification Number (OHR 000 157 727) was assigned at this time. On June 13, 2011, the Permit was further modified to remove two SWMUs and four AOCs. Corrective action work on the remaining 15 SWMUs and 1 AOC continued under the Permit. Figure 2-4 shows the SWMU and AOC locations.

The Permit was allowed to expire on June 30, 2016, and on September 16, 2016, a Consent Order was signed between Dow and USEPA that defined and governs the remaining corrective action required at the site (USEPA 2016). By 2016, RFI Phases 1 and 2 had been completed. No further action was required for 14 SWMUs and the 1 AOC. The RFI continued for SWMU 1 under the Consent Order. Table 2-2 summarizes the originally identified SWMUs and AOCs and provides the current corrective action status.

2.4 RCRA Facility Investigation Summary

The following subsection summarize the RFIs conducted since 2011.

2.4.1 RCRA Facility Investigation – Phase 1

The Phase 1 RFI was conducted from December 2011 to January 2012 and was designed to develop a basic physical conceptual site model (CSM) for the site and investigate potential releases to soil and sediment at the AOC and SWMUs identified in the Permit (CH2M 2011). The investigation included soil and drainage ditch sediment data collection as well as a screening-level human health risk assessment (SHHRA) and screening-level ecological risk assessment (SLERA) evaluation.

The Phase 1 conclusions were (CH2M 2014a):

- Exceedances of the conservative soil screening levels protective of groundwater were observed at ten SWMUs and one AOC. A sitewide groundwater investigation was recommended.
- Subsurface soil exceedances above USEPA industrial contact regional screening levels (RSLs) were found at SWMU 24. An additional soil investigation was recommended.
- Arsenic is not a site-related constituent of potential concern (COPC), and detected concentrations were consistent with Ohio background concentrations.
- No further action required was concluded for four SWMUs.
- The SHHRA and SLERA concluded that site-related COPCs are not present in soil and sediment at levels that could pose risks above the target levels, and no COPCs need to be carried forward for subsequent investigations.

2.4.2 RCRA Facility Investigation – Phase 2

The Phase 2 RFI was conducted in three stages between October 2014 and February 2016 (CH2M 2014b, 2015). Phase 2 was designed to complete delineation of the nature and extent of soil contamination identified during the Phase 1 RFI, evaluate sitewide groundwater for the presence of COPCs, and provide data to complete an SHHRA for groundwater. The Phase 1 soil SHHRA was updated with data collected during Phase 2, and a groundwater SHHRA was completed.

The Phase 2 RFI conclusions were (CH2M 2017a):

- The updated soil SHHRA conclusions did not change. No COPCs are present at levels that could pose risks above the target levels, and no COPCs need to be carried forward for subsequent investigations.
- Tetrachloroethene (PCE) and trichloroethene (TCE) were detected in groundwater above USEPA maximum contaminant levels (MCLs). Vertical aquifer profiling showed impacts above MCLs are only found in the upper portion of the aquifer. Groundwater exceeding MCLs is not migrating offsite.
- PCE and TCE in MW-08, which is near SWMU 1, exceeded USEPA groundwater-to-indoor air vapor intrusion screening levels (VISLs). The remaining monitoring well sample concentrations were below groundwater-to-indoor air VISLs.
- Additional investigation was warranted at SWMU 1 to assess the potential vapor intrusion (VI) impact from soil and groundwater COPCs for current and future onsite receptors.
- No further action was concluded for the remaining ten SWMUs and one AOC.

2.4.3 RCRA Facility Investigation – Phase 3

The Phase 3 RFI was conducted in three stages between August 2017 and June 2018 (CH2M 2016a, 2018a). This phase focused on SWMU 1 and the surrounding buildings, since no further action had been concluded for the other SWMUs and AOCs during the Phase 1 and 2 RFIs. The Phase 3 RFI was designed to assess potential risk of VI for the structures near SWMU 1 and identify the potential VI subsurface source areas. The SHHRA was updated with new soil and groundwater data collected.

The Phase 3 RFI was conducted in and around Building 505, an office building north of SWMU 1; Building 500, a warehouse south of SWMU 1; and Building 501, a maintenance shop northwest of SWMU 1 (Figure 2-7). A building use survey and HAPSITE gas chromatograph/mass spectrometer ambient air survey were conducted at Building 505. Figure 2-8 presents the exterior soil gas, subslab soil gas, indoor air, outdoor air, sewer gas, surface and subsurface soil, and groundwater sampling locations. The Phase 3 RFI conclusions are summarized below (Jacobs 2019a).

2.4.3.1 Overall

- PCE and TCE concentrations exceeded screening levels (VISLs or MCLs) within the three building investigation areas. Building 505 was the most impacted and Building 501 was the least impacted.
- Indoor air exceeded VISLs within Building 505 during the first sampling event (September 2017). Interim measures were enacted and are discussed further in Section 2.5.
- In soil gas, indoor air, soil and groundwater, PCE had the highest concentrations above screening levels and greatest extent. Significant detections of other daughter products were not observed.
- Four potential VI soil source areas were identified.

2.4.3.2 Soil

- The updated soil SHHRA conclusions did not change. No COPCs are present at levels that could pose risks above the target levels, and no further evaluation for direct contact exposure pathways in soil is needed.

- Although the soil samples were below direct contact RSLs, more elevated concentrations were used to identify potential soil source areas contributing to VI. The most elevated PCE concentrations were in the subsurface sand and gravel vadose zone soil above the water table between approximately 20 to 28 feet bgs in several isolated locations near the southern portion of Building 505, northern portion of Building 500, and the parking lot between the two buildings. Figures 2-9 through 2-11 present the PCE soil concentrations at three depth intervals: surface (0 to 2 feet bgs), shallow (5 to 10 feet bgs), and deep (21 to 29 feet bgs). Color coding is used to depict areas of higher concentrations, indicating potential source areas.
- In the fine-grained upper surface and shallow soils (0 to 10 feet bgs), the area near soil borings SS-33 and SS-02 had the highest relative concentrations (Figures 2-9 and 2-10). In the sand and gravel unit, five locations had the highest relative concentrations within the vadose zone (Figure 2-11).

2.4.3.3 Groundwater

- The updated groundwater SHRRA conclusions did not change. PCE and TCE were detected in groundwater above USEPA MCLs, but groundwater exceeding MCLs is not migrating offsite.
- The groundwater source is the SWMU 1 area, and the highest concentrations are near the southeastern corner of Building 505 and extend east-southeast through the parking lot. Figure 2-12 presents the Phase 3 SWMU 1 PCE groundwater concentrations incorporated into the sitewide plume map created during the Phase 2 RFI. The Phase 3 data refined the area of highest concentrations but did not change the overall findings.

2.4.3.4 Soil Gas and Indoor Air

- Figures 2-13 and 2-14 show the PCE and TCE exterior and subslab soil gas concentrations, respectively. Orange locations exceed VISLs on the figures. Elevated PCE soil gas concentrations were found throughout and surrounding Building 505, the parking lot, and the northern extent of Building 500. A PCE source, and to a lesser extent TCE source, representing a potential VI concern may be present in these areas.
- Indoor air exceeded VISLs within Building 505 during the September 2017 sampling event. Interim measures were enacted and discussed in detail in Section 2.5. After the interim actions were performed, subsequent indoor air sampling over 8 months showed an immediate and sustained lower indoor air concentrations below VISLs. Figure 2-15 presents the PCE and TCE indoor air sampling results.
- The building and HAPSITE surveys concluded that three floor cracks and the use of aerosol chemical cleaners containing PCE and TCE in the building interior may be sources of the indoor air exceedances in Building 505. Figure 2-15 shows the locations where cracks were sealed and where the aerosol cans were used. The sewer gas sampling indicated the sewer is not a preferential pathway for VI into the building.
- Based on the soil gas and groundwater concentrations, the updated SLHHRA concluded that the VI pathway represents a potential risk to workers in the buildings near SWMU 1. However, indoor air concentrations were below VISLs in Buildings 500 and 501 and have been below VISLs since enacting the interim measures in Building 505.;

2.5 Interim Corrective Measures

Following completion of the Phase 3 RFI activities in August and September 2017, Dow submitted the *Potential Vapor Intrusion Investigation Summary Technical Memorandum for Dow Hanging Rock Facility* (CH2M 2017b) to USEPA, which detailed the exterior and subslab soil gas and indoor air sampling findings and recommended an additional investigation. Following review of this document, USEPA requested short-term interim measures (i.e., air filtration, adjusting ventilation, alerting people inside the building to risk) be taken at Building 505 to protect plant workers using that building from volatile organic compound (VOC) exposures, specifically PCE. Interim measures were planned (CH2M 2018b) and completed by April 5, 2018 and documented in the *Interim Measures Action Summary Letter* (CH2M 2018c).

Interim measures completed in Building 505 included:

- Temporarily relocating workers and posting signs on the building doors alerting workers that PCE had been detected above the VISL
- Performing an indoor air survey using the HAPSITE to identify potential vapor entry points and interior sources
- Identifying and sealing floor cracks that could be vapor entry pathways
- Removing products containing PCE and TCE that were open and used in the interior of the building,
- Evaluating the heating, ventilation, and air conditioning system
- Placing two air purifying units in rooms with sealed cracks and formerly using/storing products containing VOCs

Indoor air concentrations decreased to below VISLs after sealing the cracks, removing and stopping use of the open spray cans inside the building, and installing the air purifying units. Five indoor air monitoring events (performance monitoring) were conducted between April and December 2018 to evaluate the interim measures. Sampling results were submitted to USEPA after each event in the *Post-Interim Measures Indoor Air Analytical Data Submittals* (CH2M 2018d, 2018e, 2018f; Jacobs 2018, 2019b). Indoor air samples have remained below VISLs since interim measure implementation.

2.6 Risk Assessment Findings Summary

An SLERA was conducted during the Phase 1 RFI (CH2M 2014a). Four SWMUs were determined to be ecologically relevant and samples collected from these locations were used in the SLERA. These SWMUs were drainage ditches (SWMUs 17, 18, and 19) and a former used filter sand pile (SWMU 29). The remaining AOC and SWMUs did not warrant further evaluation since they do not contain viable habitats. The SLERA concluded that given the level of exceedances relative to background, the limit of quality habitat, and the small size of the SWMUs, unacceptable risk to ecological receptors is not likely; therefore, no further evaluation was warranted or recommended.

An SLHHRA was conducted during the Phase 1 RFI (CH2M 2014a); as additional sampling was performed during the Phase 2 and Phase 3 RFIs, the SLHHRA was updated (CH2M 2017a; Jacobs 2019a). The following subsections provide conclusions for each potential exposure scenario.

2.6.1 Soil Direct Contact

Soil sample results from discrete depths between 0 and 10 feet bgs and drainage ditch sediment samples were evaluated for the direct contact exposure scenario. The estimated excess lifetime cancer risks (ELCRs) and noncancer hazard indexes (HIs) associated with the COPCs were within USEPA's risk management range of 1×10^{-6} to 1×10^{-4} for cancer risks and below the USEPA noncancer threshold of 1. No further evaluation is necessary for the direct contact exposure scenarios associated with current and anticipated future industrial land use at the site.

2.6.2 Groundwater Direct Contact and Ingestion

Groundwater sample analytical results collected during the RFI activities were evaluated in the SHHRA. Three VOCs (cis-1,2-dichloroethene [cis-1,2-DCE]; PCE; and TCE) were identified as COPCs in groundwater for the potable use exposure scenario. The estimated ELCR (1×10^{-4}) was equal to the high end of USEPA's risk management range of 1×10^{-6} to 1×10^{-4} for cancer risks. This was driven by the PCE and TCE concentrations. The estimated cumulative noncancer HI for groundwater (266) exceeded the USEPA noncancer threshold of 1. However, the ingestion exposure pathway is incomplete because groundwater is restricted for potable consumption onsite, and groundwater exceeding MCLs is not migrating offsite. The depth to groundwater is approximately 25 feet bgs, so the direct contact exposure pathway also is incomplete.

2.6.3 Groundwater Vapor Intrusion

PCE and TCE were identified as COPCs for the groundwater to VI pathway. The estimated ELCR (1×10^{-5}) was within USEPA's risk management range of 1×10^{-6} to 1×10^{-4} for cancer risks. The estimated cumulative noncancer HI (2) for groundwater VI was above the USEPA threshold of 1 because of the TCE concentrations in groundwater. The groundwater to VI pathway presents a potential risk to workers in the buildings adjacent to SWMU 1.

2.6.4 Soil Gas (Vapor Intrusion)

Three VOCs (PCE, TCE, and vinyl chloride) were identified as COPCs in soil gas samples for the VI pathway. The estimated ELCR (3×10^{-4}) was above USEPA's risk management range of 1×10^{-6} to 1×10^{-4} for cancer risks. The estimated cumulative noncancer HI (95) was greater than the USEPA's noncancer threshold of 1. This was driven by the PCE and TCE concentrations.

The soil gas to VI pathway presents a potential risk to workers in the buildings adjacent to SWMU 1.

2.6.5 Summary of Potential Risks

The risk assessment findings are summarized in Table 2-3. The following pathways present a potential risk to workers under current and future scenarios:

- Ingestion of groundwater – specifically PCE and TCE for the cancer risk, and cis 1,2-DCE contributes to the cumulative non-cancer risk
- VI from groundwater and soil gas – specifically PCE and TCE

3. Current Conditions

The corrective action focus is the soil gas and groundwater source area that is driving the potential risks. The RFIs have established a knowledge base for determining the soil gas and groundwater nature and extent. This section describes the current conditions and target treatment zones to support corrective measures alternative evaluation.

The human health risks are primarily driven by PCE and TCE; and therefore, are the target treatment compounds along with their degradation products. The highest concentrations are found in the SWMU 1 area, indicating this is the source area. The SWMU 1 area is the general target treatment zone. PCE has the highest concentrations and greatest extent in soil gas, soil, and groundwater concentrations. The PCE soil gas, soil and groundwater grab results are depicted on cross sections that extent west to east (A-A') and north to south (B-B') through Building 505. Cross-section locations are shown on Figure 3-1.

PCE concentrations in soil gas above VISLs extends northwest of Building 505, through the parking lot and into the northern portion of Building 500 (Figure 2-13). The cross-sections show the exterior soil gas probe screened interval, between approximately 4.2 to 5 feet bgs, encounter the shallow sand strata above the perched saturated zone at most locations (Figures 3-2 and 3-3). This sand strata could act as permeable migration pathways for soil gas. Since most soil gas probe screens were in contact with the sand strata, some results could be representative of soil gas within the migration pathways instead of localized source areas. For example, the area north of Building 505 on cross section B-B' (Figure 3-2) has elevated soil gas concentrations from probes within the sand strata; however, the soil and groundwater concentrations are lower than most other areas sampled. Overall, the target treatment zone for soil gas extends from the northeast corner of Building 501, through Building 505, the parking lot, and into the northwestern section of Building 500. This target treatment zone is shown on Figure 3-4.

Figure 2-12 shows the groundwater PCE plume extent. The western extent is defined by a non-detect groundwater grab location GW-13, located south of Building 501 and the eastern and southern extents (direction of groundwater flow) are bound by downgradient monitoring wells. The highest concentrations are found under Building 505, emanating from the GW-07 area, and flowing east, southeast. Buildings impacted by elevated groundwater concentrations include Building 505 and the northeastern extent of Building 500. Groundwater is below groundwater-to-indoor air VISLs for the rest of the site. The target treatment zone for groundwater is shown on Figure 3-4. It is similar to the soil gas target treatment zone but does not extent north of Building 505.

Although soil concentrations were below direct contact RSLs, areas of higher concentrations indicate potential soil source areas contributing to the soil gas and groundwater concentrations. Cross-section A-A', Figure 3-2, shows location SS-33/GW-21/SG-19 boring elevated PCE concentration in upper fine grain soils and the associated soil gas concentration. Figure 3-3, cross-section B-B', shows the other area of more elevated soil concentrations in the fine-grain surface soil – location SS-02 in the parking lot area. The more elevated deep soil impacts were detected in the vadose zone approximately 2 to 6 feet above the water table (Figure 2-11). Groundwater impacts generally coordinated with these areas, with the highest groundwater and vadose zone soil concentrations detected at boring SS-26/GW-07, SS-37/GW-15, SS-40/GW-17, SS-31/GW-11, and SS-32/GW-12 (Figures 3-2, 3-3, and 2-12).

3.1 Target Treatment Area Conceptual Site Model

A CSM for the soil gas and groundwater VI potential includes the following components:

- The shallow fine-grained soil unit consists of clays, silts, and sands, and is approximately 10 feet thick. The lower portion of the fine-grained soil unit is saturated (shallow saturated zone); because no confining layer is between the fine-grained soil and the more permeable sand and gravel unit, the saturation is likely held in place by capillary pressures of the fine-grained soil unit.

- The shallow fine-grained soils are underlain by a coarser-grained sand and gravel regional aquifer. The vadose zone of this unit is approximately 15 to 20 feet thick, with groundwater encountered between 26 to 29 feet bgs.
- Original surface VOC impacts may have been disturbed and spread during construction activities, masking the original source area(s).
- Surface impacts have migrated through the shallow fine-grained soil to the vadose zone and groundwater in the sand and gravel aquifer.
- The shallow fine-grained soil unit vadose zone developed high levels of PCE and TCE soil gas because the area of capillary saturation separates the fine-grained vadose zone from the sand and gravel vadose zone when the shallow saturated zone is present.
- The soil gas entered the subslab space and then into Building 505 through cracks and other openings; however, the indoor COCs also were affected by the use of products containing chlorinated solvents in portions of the building. Interim corrective measures (crack sealing, removal of PCE product use, and air purifying units) resulted in a reduction of PCE concentrations in the building to below indoor air action and screening levels.
- Elevated groundwater concentrations generally correlate with elevated soil concentrations found 2 to 6 feet above the water table.
- The groundwater PCE and TCE plumes emanate from the southwest corner of Building 505; but do not extend offsite.
- The target treatment zone correlates with the highest soil gas and groundwater PCE and TCE concentrations. This zone includes Building 501, Building 505, and the northeastern extent of Building 500. The target treatment zone is depicted on Figure 3-4.

4. Proposed Corrective Measures

This section evaluates remedial alternatives and presents the proposed corrective measures to address VI risks in the SWMU 1 area and groundwater ingestion risks.

4.1 Exposure Pathways

This CMP was developed to protect human health and the environment by addressing the potential human health risks and associated potential exposure pathways, described in Section 2. The current and future potential exposure pathways for the site are:

- Direct Contact – Soil and sediment direct contact risks associated with current and anticipated future industrial land use at the site are within USEPA's risk management range for cancer risks and below the USEPA noncancer threshold. An existing IC is in place that restricts future use of the site to commercial and industrial use only.
- Groundwater Ingestion – PCE and TCE exceed MCLs within the site boundary. An existing IC is in place that prevents potable use and restricts groundwater use to industrial purposes only.
- Inhalation – Based on the exterior and subslab soil gas and groundwater concentrations, the VI pathway represents a potential risk to workers in the buildings in proximity to SWMU 1.

4.2 Remedial Action Objectives

Based on the potential human health risks and associated exposure pathways, RAOs have been identified to address the potential human health risks and associated exposure pathways for PCE and TCE at the site. The RAOs (listed below) were developed in consideration of current and reasonably expected future land use:

- Protect human health and the environment from current and future unacceptable risks associated with historical releases of hazardous waste or hazardous constituents at or from the site
- Prevent groundwater containing PCE, TCE and associated degradation products (site-related CVOCs) from migrating offsite at concentrations exceeding USEPA MCLs
- Reduce soil, groundwater and soil gas concentrations in the SWMU 1 area to reduce potential VI risks in the surrounding buildings to acceptable levels
- Maintain the existing ICs regarding drinking water restrictions and industrial/commercial use

4.3 Corrective Measures Technology Screening

Dow conducted an evaluation of remedial technologies to address the SWMU 1 area VI risks and meet the other RAOs for the site. Technologies were identified based on the CSM and prior remediation experience under similar site conditions. Table 4-2 identifies potentially applicable technologies for addressing SWMU 1 VI risks.

Technologies were screened based on advantages, limitations, effectiveness/certainty, timeframe, effect on Building 505, and relative costs. The remedies that met the initial screening criteria include thermal treatment technology, air sparging (AS) technology, soil vapor extraction (SVE) technology, and excavating impacted soil. These technologies were advanced for evaluation of remedial alternatives. A general description of each technology alternative is provided below:

- Thermal treatment introduces heat to impacted soil to facilitate volatilization of VOCs.
- AS injects air into contaminated groundwater to volatilize VOCs into the overlying unsaturated (vadose) zone.

- SVE involves removing VOCs in soil in the vadose zone via air extracted from and sometimes injected into the vadose zone. SVE is commonly implemented in conjunction with AS to remove the generated vapor-phase contamination from the vadose zone. SVE strips VOCs from soil and transports the vapors to ex-situ treatment systems for VOC destruction, recovery, or discharge. SVE also can be used to remove vapors stripped from VOC-contaminated soil by other soil treatment methods such as thermal treatment technologies at sites where the soil or constituents are not amenable to SVE treatment alone.
- Excavation involves physically removing contaminated soil, loading it for transportation offsite, and offsite disposal.

4.4 Corrective Measures Alternative Evaluation

The technologies that passed screening were used to develop four remedial alternatives. The alternatives were evaluated using the following criteria:

- Effectiveness—This criterion is based on a combination of the remedy's ability and speed to reduce risks to future workers in Buildings 501 and 505 and the northern portion of Building 500 through the VI pathway. The effectiveness of the remedy in this context considered uncertainty in the remedy's effectiveness because of site conditions or limitations in available site characterization data.
- Implementability—This criterion also considers the ability of the remedy to be implemented considering site-specific conditions such as COCs and site constraints (legal, onsite facilities, adjoining properties, etc.).
- Constructability—This criterion evaluates the ability of the remedy to be built under existing site operating conditions.
- Cost—This criterion considers the capital cost for implementing the remedy as well as the long-term monitoring, operations, and maintenance costs.

Institutional Controls

ICs will be part of the final remedy and can be coupled with each alternative evaluated. These ICs are:

- Restrict land use to commercial/industrial uses
- Prohibit the extraction of groundwater for potable uses

ICs were implemented on the parcels during the property sale in 2017.

Groundwater Monitoring

To meet the RAO to mitigate site-related CVOCs exceeding MCLs from migrating offsite, groundwater monitoring will be a component of the final remedy. A groundwater monitoring plan will be developed based on the selected alternative to monitor groundwater flow direction and downgradient site-related CVOC concentrations during corrective measures implementation and operation. The monitoring would continue until CVOCs no longer exceed MCLs, or until the plume has been shown to be stable or shrinking following completion of the active remediation.

4.4.1 Alternative 1 – Air Sparge/Soil Vapor Extraction

AS is an in-situ technology involving injecting air into an aquifer to induce mass transfer (stripping) of VOCs from groundwater. The injected air rises through the saturated zone in a complex and non-uniform series of finger-like channels, the paths of which are influenced by heterogeneity in subsurface lithology. For this approach, three horizontal AS wells would be installed at 50 feet bgs, approximately 25 feet below the water table. The horizontal AS wells would be installed with screen intervals positioned to span the target treatment zone, ranging from 300 to 350 feet. The expected influence zone of the AS wells is expected to be 40 feet on either side (80 feet total). Figures 4-1a and 4-1b show the conceptualized layout for the horizontal wells. AS wells would be connected to a blower through below-grade system piping.

In addition to the three horizontal AS wells, four horizontal SVE wells would be installed within the treatment area vadose zone at 20 feet bgs, approximately 10 feet above the water table, to promote air flow within the vadose zone and capture vapors released by the horizontal AS wells. Three of the horizontal SVE wells would be nested with the AS wells. The nested horizontal SVE wells would have screen intervals matching the corresponding AS well. An additional horizontal SVE well would be placed under Building 505 to capture VOC vapors released by AS wells. The screen intervals of the horizontal SVE wells would range from 300 to 350 feet. The expected influence zone of horizontal SVE wells is 80 feet on either side (160 feet total).

The highest concentrations of PCE and TCE in soils are in highly transmissive lithology (i.e., sandy gravel) immediately above the water table. The horizontal SVE wells would promote air flow through the vadose zone, thereby promoting volatilization of VOCs in vadose soil. As air is introduced into groundwater, VOCs are stripped out of the groundwater, and the SVE wells would capture the VOC vapors in the vadose zone.

4.4.1.1 Effectiveness

AS/SVE would be effective at treating the deeper more transmissive sand and gravel lithology which contains the highest concentrations of PCE and TCE and are likely acting as an ongoing source of groundwater contamination and soil gas at the site. However, another goal of the AS/SVE is to dry out and address impacts in the fine grain upper soils. AS/SVE would be effective at reducing concentrations of PCE and TCE in site groundwater. RAOs are expected to be met within 5 years of active treatment.

4.4.1.2 Implementability

This remedy is implementable. Both AS and SVE wells would be installed using horizontal drilling methods that would not disrupt operations at Building 505 or nearby parking lots. The treatment building for the SVE system would be staged away from Building 505; therefore, treatment system operations and maintenance would have little impact on site operations.

4.4.1.3 Cost

The estimated cost of installing the AS/SVE system is $3.2 million. Table 4-2 provides the range of magnitude construction and operations and maintenance cost estimates.

4.4.2 Alternative 2 – Air Sparge/Soil Vapor Extraction with Shallow Excavation

Alternative 2 consists of the components of the AS/SVE system described in Alternative 1 to address CVOCs in deeper, transmissive soil; however, Alternative 2 addresses two areas of more elevated CVOCs in fine-grained shallow soil that may be contributing to soil gas concentrations near the buildings. Based on available shallow soil data, two areas were identified for excavation (Figure 4-2). The first is between Buildings 501 and 505 and addresses more elevated concentrations of PCE in shallow soil to a depth of 10 feet bgs. A second area north of SWMU 1 in the parking lot has been proposed to address easily accessible soil to a depth of 5 feet bgs. The general extents of conceptual shallow excavations are shown on Figure 4-2. A slurry-stabilized trench is planned for the first area during excavation activities to mitigate risk to the structural foundations of Buildings 501 and 505 during implementation and maximize the soil removal area.

4.4.2.1 Effectiveness

As discussed above, the AS/SVE system would be effective at addressing the deeper, more transmissive sand and gravel at the site, which is likely acting as an ongoing source of PCE and TCE in soil gas and groundwater at the site. The effectiveness of shallow excavation to address the finer-grained shallow soil in conjunction with AS/SVE is uncertain. Shallow excavation would remove surficial soil containing known higher concentrations of PCE and TCE outside the footprint of Building 505. However, soil containing PCE and TCE would remain under the Building 505 footprint following shallow excavation.

4.4.2.2 Implementability

Shallow excavation has moderate implementability, as it would disrupt activities near Building 505 for approximately 30 days and requires a newer excavation method (i.e., slurry-stabilized trenching), which is not implementable near underground utilities. Few subcontractors have experience implementing this method, making shallow excavation less implementable than AS/SVE alone.

4.4.2.3 Cost

The estimated cost of slurry-stabilized shallow soil excavation is $600,000. The estimated total alternative cost is $3.8 million Table 4-2 provides the range of magnitude construction and operations and maintenance cost estimates.

4.4.3 Alternative 3 – Air Sparge/Soil Vapor Extraction with Thermal Enhancement

This alternative includes the components of the AS/SVE system described in Alternative 1 with the addition of thermal treatment of shallow soil, targeting soil from ground surface to 10 feet bgs. For this alternative, a commercially available electric heating method would be installed under Building 505 and extend across the parking lot toward Building 500. The total treatment area is approximately 37,000 square feet, heating approximately 14,000 cubic yards of shallow soil to accelerate removal of shallow, subsurface VOCs. Figure 4-3 shows the conceptual thermal treatment target areas.

For this alternative development and analysis, using thermal conduction heating (TCH) was assumed. Site conditions are equally amendable to applying electrical resistance heating (ERH), which also is a viable and commercially available technology for in-situ thermal treatment. The performance of TCH and ERH heating technologies is assumed to be comparable, and both technologies exhibit similar cost competitiveness. Ancillary infrastructure and construction requirements for each heating method are similar, and neither technology provides an identifiable technical nor logistical advantage.

Shallow soil would be heated using TCH or ERH to increase the volatility of PCE and TCE; heating also would promote constituent desorption from the fine-grained soil units in the shallow subsurface. Following volatilization, PCE and TCE would be collected through shallow SVE wells installed within the parking lot and through the floor slab foundation of Building 505. Application of shallow soil heating described in this alternative requires AmSty to vacate Building 505 during active thermal operations. Current occupants of Building 505 would be relocated to temporary facilities outside the work area. Similarly, materials currently stored in Building 505 would be moved to an alternate location onsite to maintain accessibility during thermal treatment operations.

Construction of the thermal treatment system would entail installing electric-powered heaters, geometrically distributed on 15-foot centers across the treatment area. Access to electric power with sufficient capacity to support operation of a vendor-supplied electric heating system was assumed for cost estimating. Within Building 505, heaters would be co-located with SVE wells to minimize drilling requirements within the structure. A limited-access drill rig with sonic capabilities would be used for well placement inside the building. In the parking area outside Building 505, independent heater and SVE wells would be installed using conventional equipment and methods.

Performance of the heating and SVE systems would be monitored using subsurface temperature and vacuum pressure measurements during active treatment operations. Wells used to measure temperature and vacuum pressure would be distributed throughout the heated area. A combined temperature/pressure monitoring point would be installed for every 1,000 square feet of treatment area.

SVE wells would be centrally connected to the main vacuum blower supplied for the SVE system described in Alternative 1. Since extracted vapor temperature will be elevated and saturated with moisture (especially once steam temperatures are reached), a front-end treatment operation to cool and condense extracted vapor would be installed. Following cooling, extracted vapor would be treated using granular activated carbon before atmospheric discharge.

Upon completion of thermal treatment operations and during demobilization activities, the thermal treatment subcontractor would remove the front-end cooling unit operation. Liquid produced by vapor cooling operations would be collected in a gravity separator vessel and treated using liquid-phase granular activated carbon before sanitary sewer discharge. As SVE operations have the potential to also produce a small volume of condensate, the liquid collection, treatment, and conveyance equipment used during thermal treatment would be retained to support the AS/SVE system, which would be expected to operate for a longer period before treatment objectives are met for deeper soil and groundwater.

4.4.3.1 Effectiveness

As discussed previously, the AS/SVE system would be effective at addressing the deeper, more transmissive sand and gravel at the site, which likely is acting as an ongoing source of PCE and TCE in soil gas and groundwater. The proposed thermal treatment of shallow soil, in conjunction with AS/SVE, would be effective for addressing the shallow, fine-grained soil in the target treatment zone. As shown on Figure 4-3, the thermal enhancement targets the areas identified during investigation activities to contain the highest concentrations of known impacts in shallow soil as well as soil under Building 505.

4.4.3.2 Implementability

Alternative 3 would have moderate to low implementability. The thermal system would be readily constructible through multiple commercial vendors, and thermal treatment would be expected to take place in less than 1 year. However, thermal remediation would require site occupants and materials stored in Building 505 to be relocated during thermal treatment. Access to Buildings 500 and 501 also may be affected by Alternative 3; therefore, the thermal treatment alternative is less implementable than shallow excavation and AS/SVE only.

4.4.3.3 Cost

The estimated cost of enhanced thermal treatment of soil is $4.6 million. The estimated total alternative cost is $7.8 million. Table 4-2 provides the range of magnitude construction and operations and maintenance cost estimates.

4.5 Proposed Final Corrective Measure

Alternative 1 (AS/SVE) is the proposed final corrective measure for the site because of its effectiveness, implementability, lowest cost, and relatively low impact to site operations. Alternative 2 (AS/SVE with shallow excavation) was not selected because of its lower effectiveness, lower implementability and higher cost. Ultimately, Alternative 2 is no more effective than Alternative 1 since removing two small areas of soil would not likely affect the overall subslab soil gas concentrations under Buildings 505 and 500. Alternative 3 (AS/SVE with thermal enhancement) was not selected because of its lower implementability and higher cost.

5. Schedule

Table 5-1 shows the estimated schedule to finalize the remedy design, implement the final corrective measures, and submit a Final Remedy Construction Completion Report. Implementation of the corrective measures will occur after USEPA issues the Final Decision, which follows a public comment period.

6. References

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Tables

Table 2-1. Regulatory Summary

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

Year	Regulatory Event Summary
1980	Facility submits a RCRA Part A permit application (Tetra Tech 2000).
1981	Facility issued an Ohio Hazardous Waste Facility Installation and Operation Permit (Tetra Tech 2000).
1982	USEPA approves RCRA Part A interim status for the facility (Tetra Tech 2000).
1986	Facility requests RCRA Part A and B permit application modification to include a hazardous waste storage tank (Tetra Tech 2000).
1989	Facility applies for an RCRA permit application modification to include an additional storage process using containers (Tetra Tech 2000).
	Preliminary Review/Visual Site Inspection Report submitted to USEPA (A.T. Kearney 1989).
2000	Updated Preliminary Review/Visual Site Inspection Report submitted to USEPA (Tetra Tech 2000).
2006	USEPA issues RCRA permit for the Hanging Rock Plant, under USEPA Identification Number OHO 039 128 913, containing requirements for the combustion of hazardous waste in boilers and corrective action of 16 SWMUs and 5 AOCs.
2008	Ownership of the boilers and certain operational assets were transferred to Americas Styrenics LLC.
2010	RCRA permit modified to delete the boiler-related permit conditions (boilers were closed in 2009), remove Dow as an "operator" under the permit to reflect the lack of any operator of a hazardous waste unit, and clarify that Dow, as the property owner, remained responsible for compliance with the corrective action requirements in the permit.
	The Ohio Environmental Protection Agency assigned an additional Identification Number (OHR 000 157 727) for the facility.
2011	RCRA permit modified to remove two SWMUs and four AOCs from the permit.
	Final RFI Phase 1 Work Plan approved by USEPA (CH2M 2011).
2014	Final RFI Phase 1 Report approved by USEPA (CH2M 2014a).
	Final RFI Phase 2 Work Plan approved by USEPA (CH2M 2014b).
2015	Final Additional RFI Phase 2 Investigation Activities Technical Memorandum approved by USEPA (CH2M 2015).
2016	RCRA permit allowed to expire.
	Administrative Order on Consent signed between Dow and USEPA.
	RCRA Corrective Action Documentation of Environmental Indicator Determination Current Human Exposures Under Control and Migration of Contaminated Groundwater Under Control submitted to USEPA (CH2M 2016b).
	RCRA RFI Phase 3 Work Plan submitted to USEPA (CH2M 2016a).
2017	Final Phase 2 RFI Report approved by USEPA (CH2M 2017a).
	Potential Vapor Intrusion Investigation Summary Technical Memorandum submitted to USEPA (CH2M 2017b).
2018	Final Additional Phase 3 RFI Work Plan approved by USEPA (CH2M 2018a).
	Potential Vapor Intrusion Interim Measures Action Plan approved by USEPA (CH2M 2018b).
	Interim Measures Action Summary Letter approved by USEPA (CH2M 2018c).
	One-week Post-Interim Measures Indoor Air Analytical Submittal provided to USEPA (CH2M 2018d).
	One-month Post-Interim Measures Indoor Air Analytical Submittal provided to USEPA (CH2M 2018e).
	Two-month Post-Interim Measures Indoor Air Analytical Submittal provided to USEPA (CH2M 2018f).
	Four-month Post-Interim Measures Indoor Air Analytical Submittal provided to USEPA (Jacobs 2018).
2019	Eight-month Post-Interim Measures Indoor Air Analytical Submittal provided to USEPA (Jacobs 2019a).
	Phase 3 RFI Report approved by USEPA (Jacobs 2019b).

Notes:
AOC = area of concern
CH2M = CH2M HILL Engineers, Inc.
Dow = The Dow Chemical Company
Jacobs = Jacobs Engineering Group Inc.
RCRA = Resource Conservation and Recovery Act
RFI = Resource Conservation and Recovery Act facility investigation
SWMU = solid waste management unit
USEPA = U.S. Environmental Protection Agency

Table 2-2. List of Solid Waste Management Units and Areas of Concern - 2006 RCRA Permit

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

SWMU / AOC	Corrective Action Status
SWMU 1 – Former Flaring Pad	Interim Corrective Measures Implemented, Final Corrective Measures Development
SWMU 7 – Former Roadside Staging Area	Removed via permit modification
SWMU 8 – Former Waste Fuel Storage Tanks	Removed via permit modification
SWMU 11 – Satellite Accumulation Area - Ethafoam Plant	No Further Action Required – RFI Phase 1
SWMU 12 – Former Methylene Chloride Cleaning Tank	No Further Action Required – RFI Phase 1
SWMU 15 - Two Section Septic Tank System	No Further Action Required – RFI Phase 2
SWMU 17 - Stormwater Drainage System	No Further Action Required – RFI Phase 2
SWMU 18 – Drainage Ditch to Big Thief Creek	No Further Action Required – RFI Phase 2
SWMU 19 – Drainage Ditch to North	No Further Action Required – RFI Phase 1
SWMU 24 – Process Sewer Line	No Further Action Required – RFI Phase 2
SWMU 25-28 – Former Wastewater Treatment System	No Further Action Required – RFI Phase 2
SWMU 29 – Former Used Filter Sand Pile	No Further Action Required – RFI Phase 1
SWMU 36 – Former 250-gallon Pressurized Storage Tanks	No Further Action Required – RFI Phase 2
SWMU 37 – Fire Protection Collection Basin	No Further Action Required – RFI Phase 2
AOC A - Styrene Spill Near Pump for Styrene Storage Tanks	Removed via permit modification
AOC B - Blowing Agent Release	Removed via permit modification
AOC C - Process Filter Area	Removed via permit modification
AOC D – Underground Catalyst Storage Tank	No Further Action Required – RFI Phase 2
AOC E - Anecdotal Release Information	Removed via permit modification

Notes:

AOC = area of concern
RFI = Resource Conservation and Recovery Act facility investigation
SWMU = solid waste management unit

Table 2-3. Summary of Cumulative Cancer Risks and Noncancer Hazard Indexes for Soil, Groundwater, and Exterior Soil Gas (Maximum Detected Concentration)

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

Media	Cumulative Cancer Risk	Primary Contributors to Cumulative Cancer Risk[a]	Cumulative Noncancer Hazard Index	Primary Contributors to Cumulative Noncancer Hazard Index[b]
Surface Soil - Industrial[c]	No COPCs identified			
Subsurface Soil - Industrial[c]	No COPCs identified			
Groundwater - Residential (Potable Use)	1E-04	PCE (20%), TCE (80%)	266	Immune HI = 182, due to TCE Urinary HI = 15, due to cis-1,2-DCE Nervous HI = 68, due to PCE Ocular HI = 68, due to PCE Developmental HI = 182, due to TCE
Groundwater - Industrial (Vapor Intrusion)	1E-05	PCE (38%), TCE (62%)	3	Immune HI = 2, due to TCE Nervous HI = 1, due to PCE Ocular HI = 1, due to PCE Developmental HI = 2, due to TCE
Exterior Soil Vapor - Industrial (Vapor Intrusion)	3E-04	PCE (62%), TCE (38%)	95	Immune HI = 41, due to TCE Nervous HI = 54, due to PCE Ocular HI = 54, due to PCE Developmental HI = 41, due to TCE

[a] Primary contributors to cumulative cancer risk are COPCs which contribute to a cumulative cancer risks of 1E-05 or greater.

[b] Primary contributors to cumulative noncancer hazard index are COPCs that contribute to a target organ HI of 1 or greater.

[c] Evaluation of VOCs only. Surface soil and subsurface soil represent the 0-2 feet and 0-10 feet below ground surface sample depth intervals, respectively.

Notes:
COPC = constituent of potential concern
DCE = dichloroethene
HI = hazard index
PCE = tetrachloroethene
TCE = trichloroethene

Table 4-1. Preliminary Technology Screening Table

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

Technology	Advantages	Limitations	Effectiveness/Certainty	Timeframe	Relative Costs	Effect on Building 505	Retained?
Air Sparge (AS)	• PCE/TCE are highly volatile and amenable to treatment with AS. • Treats both vadose soil and groundwater near buildings. • Takes advantage of gravel/sand in aquifer and vadose zone. • Addresses highest concentrations of PCE in vadose soils. • Addresses known sources of VI and groundwater impacts.	• Accessing buildings to install wells may be difficult; however, this may be mitigated by installing horizontal wells. • May not be effective for perched capillary groundwater in shallow depths • Less effective for tighter lithologies at shallow depths.	• High – effective technology for PCE/TCE in vadose zones/aquifers composed of gravel/sand. • Less effective/certain for tighter lithologies at shallow depths.	Soil: 3-5 years Groundwater: 3-5 years	$$$$	• Would need to align system construction with Building 505 renovation or install horizontal wells. • Could reduce indoor noise by installing blowers outside of Building 505 for vertical scenario.	Yes.
Soil Vapor Extraction (SVE)	• PCE/TCE are highly volatile and amenable to treatment with SVE. • Treats both vadose soil and groundwater near buildings. • Takes advantage of gravel/sand in aquifer and vadose zone. • Addresses highest concentrations of PCE in vadose soil. • Addresses known sources of VI and groundwater impacts.	• Accessing buildings to install wells may be difficult; however, this may be mitigated by installing horizontal wells. • May not be effective for perched capillary groundwater in shallow depths. • Less effective for tighter lithologies at shallow depths.	• High – effective technology for PCE/TCE in vadose zones/aquifers composed of gravel/sand. • Less effective/certain for tighter lithologies at shallow depths.	Soil: 3-5 years Groundwater: 3-5 years	$$$$	• Would need to align system construction with Building 505 renovation or install horizontal wells. • Could reduce indoor noise by installing blowers outside of Building 505 for vertical scenario.	Yes.
Enhanced Reductive Dechlorination (ERD) + Bioaugmentation	• Proven technology for PCE/TCE in groundwater. • Gravel/sand aquifer amenable for ERD injections. • Uses less dangerous, food-grade materials.	• Does not address soil impacts. Soil will act as continuing source for groundwater and VI. • Potential subslab methane and vinyl chloride issues.	• Low – technology does not address soil impacts that act as continuing source for groundwater and VI.	Soil: Indefinite Groundwater: Indefinite	$$	• Potential subslab methane and vinyl chloride (VI concern).	No.
In-Situ Chemical Oxidation	• Effective technology for PCE/TCE source zones in groundwater	• Does not address soil impacts. Soil will act as continuing source for groundwater and VI. • Costly reagents. • Health and safety concerns with reagents.	• Low – technology does not address soil impacts that act as continuing source for groundwater and VI. • Typically, more effective for source zones in groundwater.	Soil: Indefinite Groundwater: Indefinite	$$$	• Exclusion zone necessary during implementation and multiple injection episodes likely.	No.
Subgrade Biogeochemical Reactor	• Proven technology for PCE/TCE in soil source zones and groundwater. • Requires less injection infrastructure than ERD. • Removes some source areas in soil by excavation. • Remaining source zone in soil treated by infiltration with reducing groundwater. • Groundwater treated by similar mechanism as ERD. • Increased residence time for groundwater by recirculation.	• Highest soil concentrations are immediately above water table, below Building 505. • Difficult to excavate soil source areas. • Potential subslab methane and vinyl chloride issues.	• Low – difficult to address soil impacts underneath Building 505 that act as source of VI or groundwater contamination.	Soil: Indefinite Groundwater: Indefinite	$	• Exclusion zone necessary during excavation and installation. • Potential subslab methane and vinyl chloride (VI concern).	No.
Thermal	• PCE/TCE are highly volatile and amenable to treatment with thermal/SVE. • Able to treat PCE/TCE in tighter lithologies. • Not limited by perched groundwater. • Able to address PCE/TCE in shallow soils underneath buildings.	• Increases amount of infrastructure required for treatment beneath buildings. • Not cost effective for non-discreet source area. • Highest concentrations in surficial soil are not located underneath buildings. • Highest concentrations in deep soil are in sand and gravel, which are not effectively heated with thermal technology. • Difficult to address groundwater impacts in highly transmissive aquifer	• High effectiveness for PCE/TCE in fine-grained, shallow soil. • Less effective for PCE/TCE in sand and gravel lithology in deeper zones. • Less effective for treating groundwater impacts in highly transmissive aquifer.	Shallow Soil: < 2 years	Shallow soil: $$$$ Shallow and Deep Soil: $$$$$	• Would need to align system construction with Building 505 renovation. • Could reduce indoor noise by installing blowers outside of buildings. • Tenants could potentially lose use of the buildings during treatment, depending on the selected thermal technology.	Yes. Retained for shallow soil.
Shallow Excavation	• The highest concentrations of PCE/TCE in shallow soil outside the footprint of buildings can be easily addressed with excavation. • Excavation removes soils affected with PCE/TCE and replaces with non-impacted material.	• Does not address soils under Building 505. • Does not address the ongoing source of soil gas and groundwater impacts in deep soils.	• High effectiveness/certainty for shallow soils that are not under buildings.	~ 1 month	$$	• Potential building access restrictions. • Shallow excavation would take place along southwestern corner of Building 505 and eastern side of Building 501, and in the parking lot.	Yes. Retained to address shallow soils.

Notes:

AS = air sparging
SVE = soil vapor extraction
ERD = enhanced reductive dichlorination
TCE = trichloroethene
PCE = tetrachloroethene
VI = vapor intrusion

Table 4-2. Estimated Costs for Remedial Alternatives

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

		Alternative 1	Alternative 2	Alternative 3
	Remedial Technology	Horizontal Air Sparge and Soil Vapor Extraction	Horizontal Air Sparge and Soil Vapor Extraction and Shallow Soil Excavation	Horizontal Air Sparge and Soil Vapor Extraction and Shallow Thermal Treatment
	Brief Description	Three horizontal sparge wells (50 ft spacing) and two horizontal SVE wells (100 ft spacing) to treat deep soils and groundwater. AS and SVE wells will be nested. VGAC vapor treatment.	AS/SVE to treat deep soils and groundwater. Slurry-stabilized excavation and backfill of shallow soils between Buildings 505 and 501 and in parking lot.	AS/SVE to treat deep soils and groundwater. Thermal treatment of shallow soils beneath Building 505, in the parking lot, and road south and west of Building 505.
Total Estimated Direct Capital Construction Cost		$2,144,000	$2,750,000	$4,734,000
Total Estimate Operations and Maintenance Cost		$1,069,000	$1,069,000	$3,038,000
Total Initial Cost		$3,213,000	$3,819,000	$7,772,000
Upper Range of Magnitude (+50%)		$4,819,500	$5,728,500	$11,658,000
Lower Range of Magnitude (-30%)		$2,249,100	$2,673,300	$5,440,400
Total Estimated Cost		**$3,213,000**	**$3,819,000**	**$7,772,000**

Note:

AS/SVE = Air Sparge/Soil Vapor Extraction

Table 5-1. Estimated Schedule for Proposed Corrective Measures Implementation

Corrective Measures Proposal

The Dow Chemical Company Former Hanging Rock Plant, Ironton, Ohio

Task	Timeframe
Submit 60% Design to USEPA for Review	90 days after USEPA issues Final Decision
Submit 90% Design to USEPA for Review	60 days after USEPA issues 60% Design comments
Subcontractor Procurement	60 days after USEPA 90% Design approval
Field Implementation	60 days after final subcontractor award
Draft Construction Completion Report	90 days after construction completion
Draft Operations and Monitoring Plan	90 days after construction completion
Final Construction Completion Report	30 days after resolving USEPA comments
Final Operations and Monitoring Plan	30 days after resolving USEPA comments

Notes:

Dow = The Dow Chemical Company

USEPA = U.S. Environmental Protection Agency

Figures

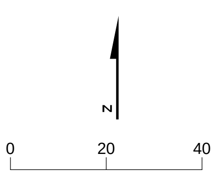


FIGURE 2-1
Facility Location Map
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

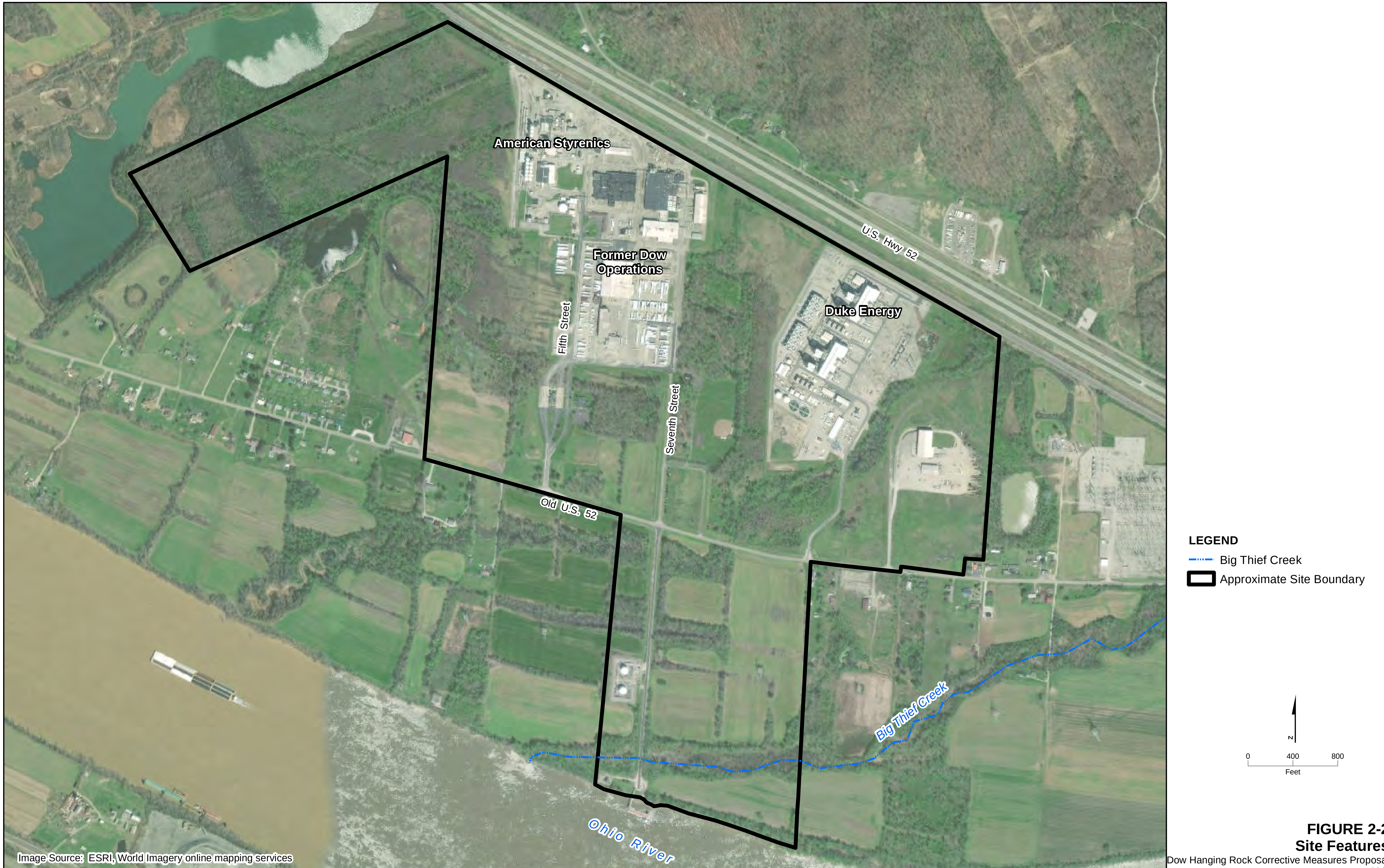


FIGURE 2-2
Site Features
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

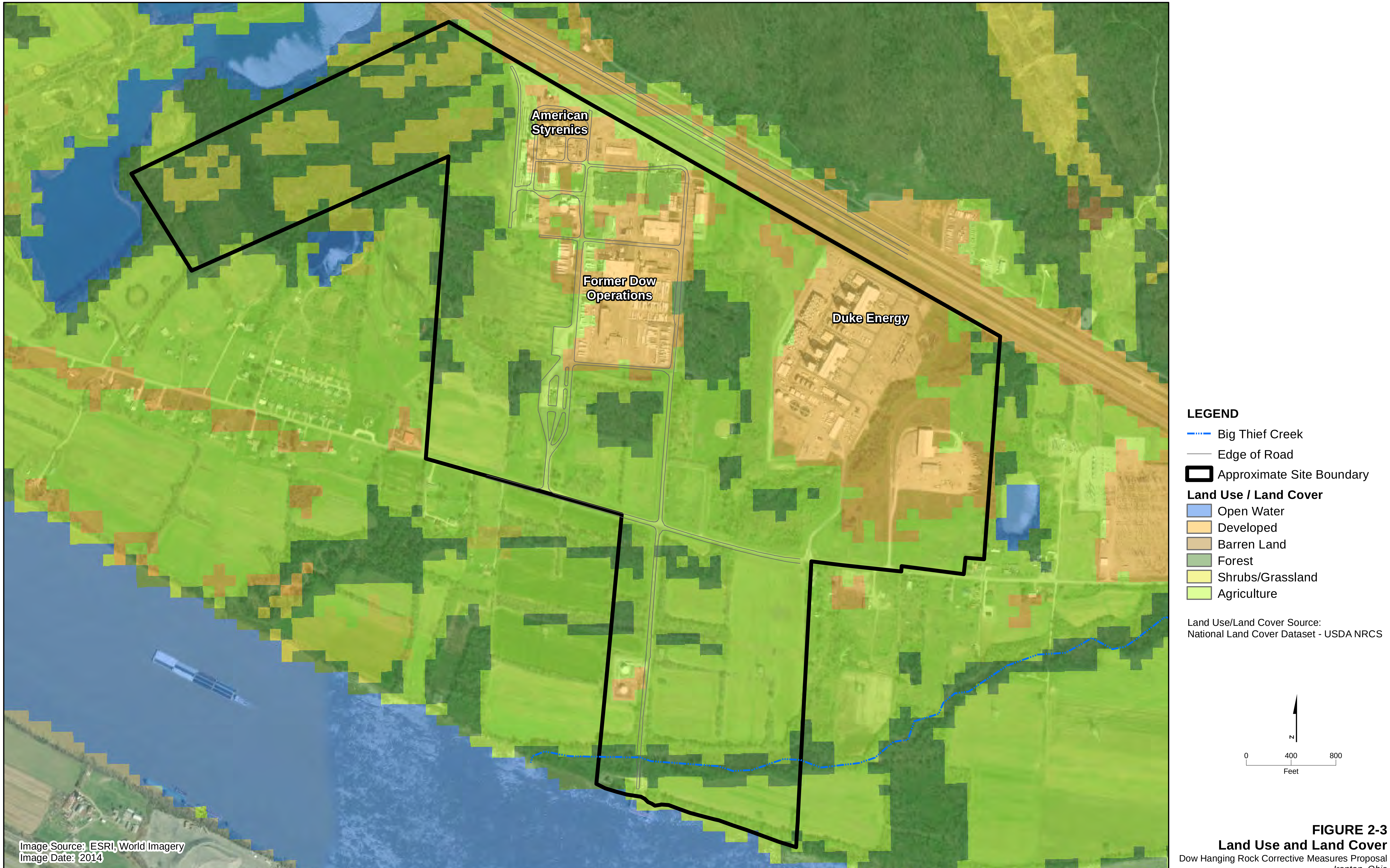
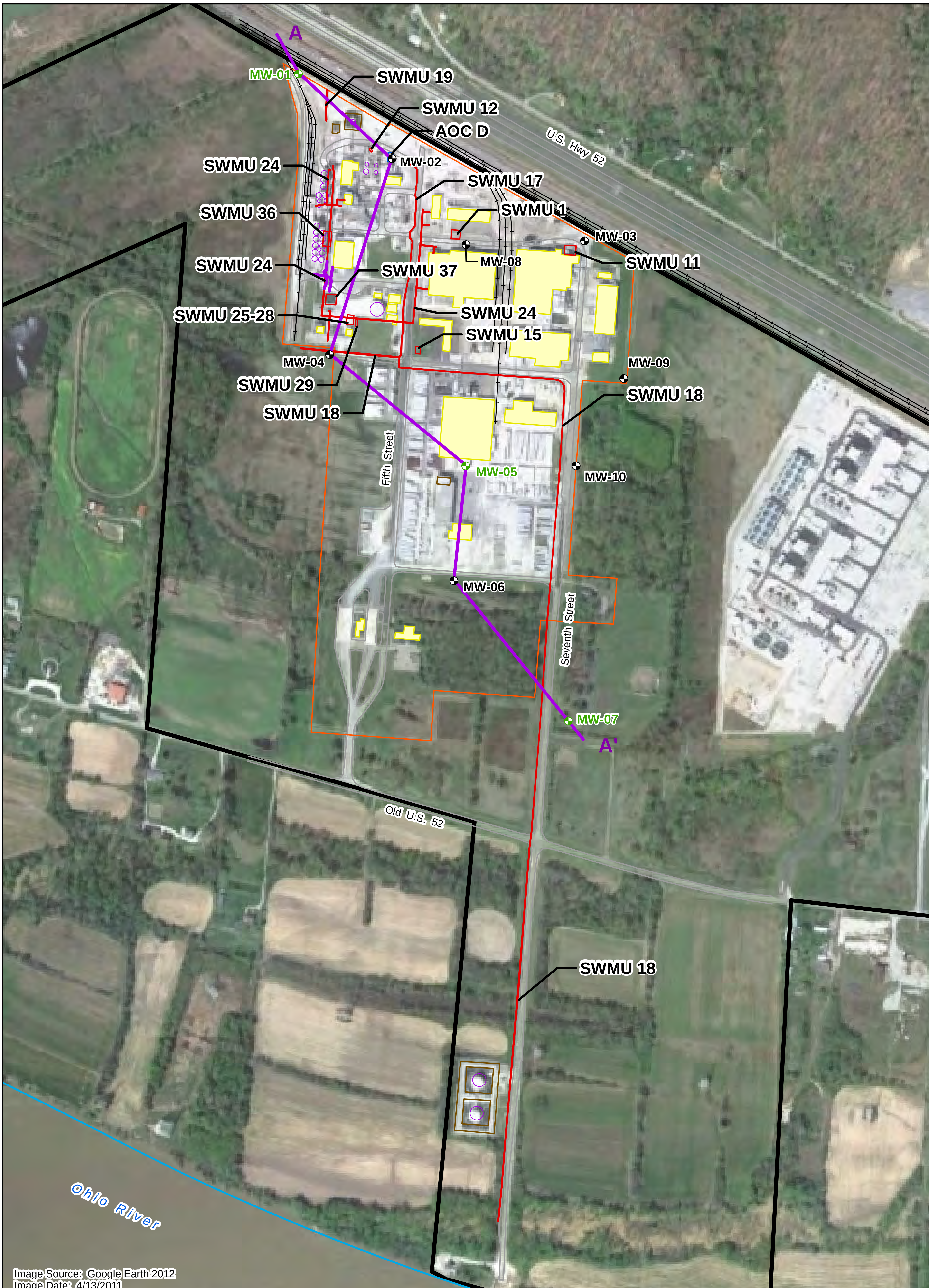


FIGURE 2-3
Land Use and Land Cover
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio



LEGEND

- Approximate Site Boundary
- AOC
- SWMU
- Building
- Miscellaneous Structure
- Tank
- Railroad
- Fence
- Edge of Road
- Cross Section Location
- Monitoring Well
- Monitoring Well / Deep Boring

N

0 250 500
Feet

FIGURE 2-4
SWMU, AOC and Monitoring Well Locations
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

JACOBS

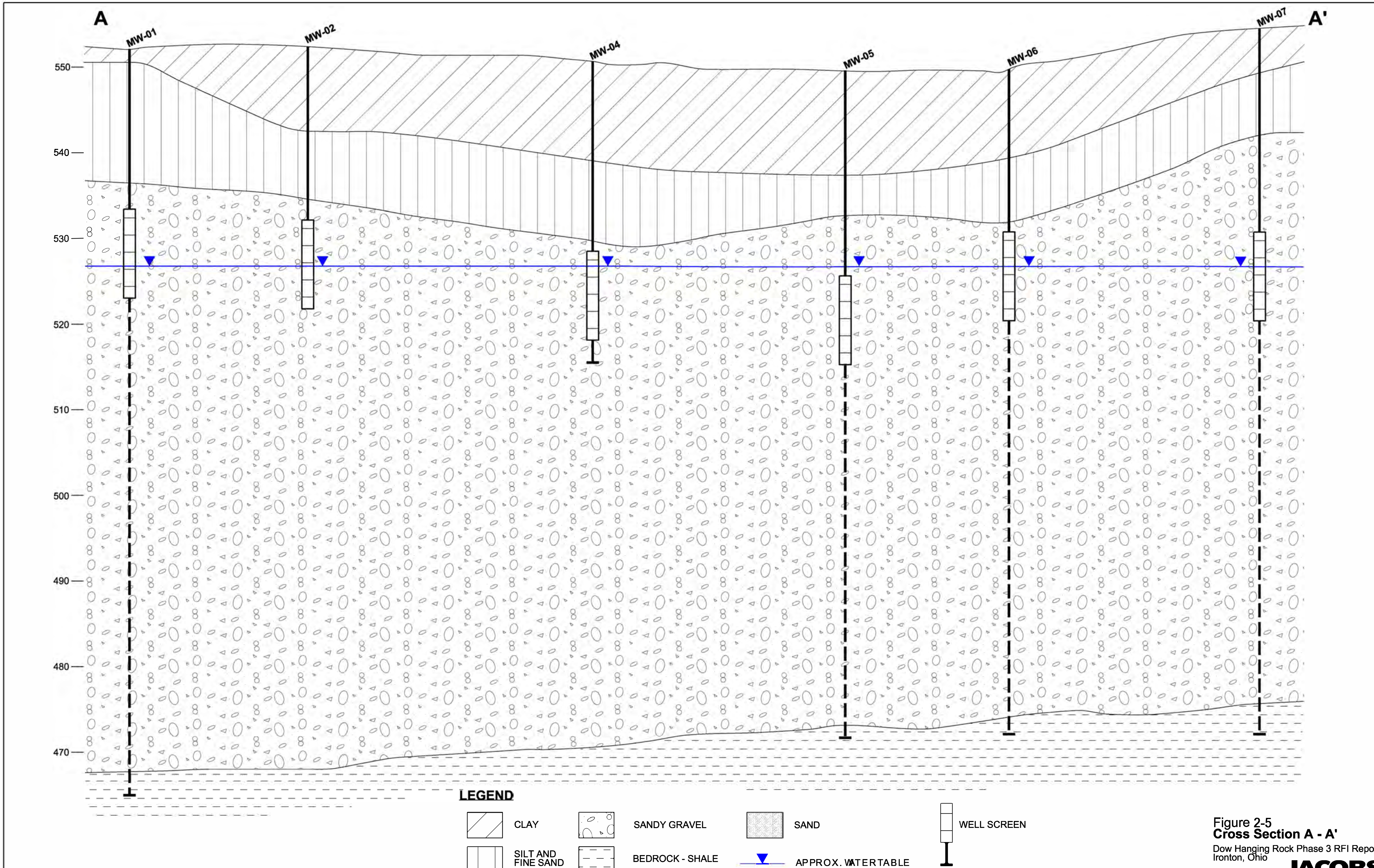
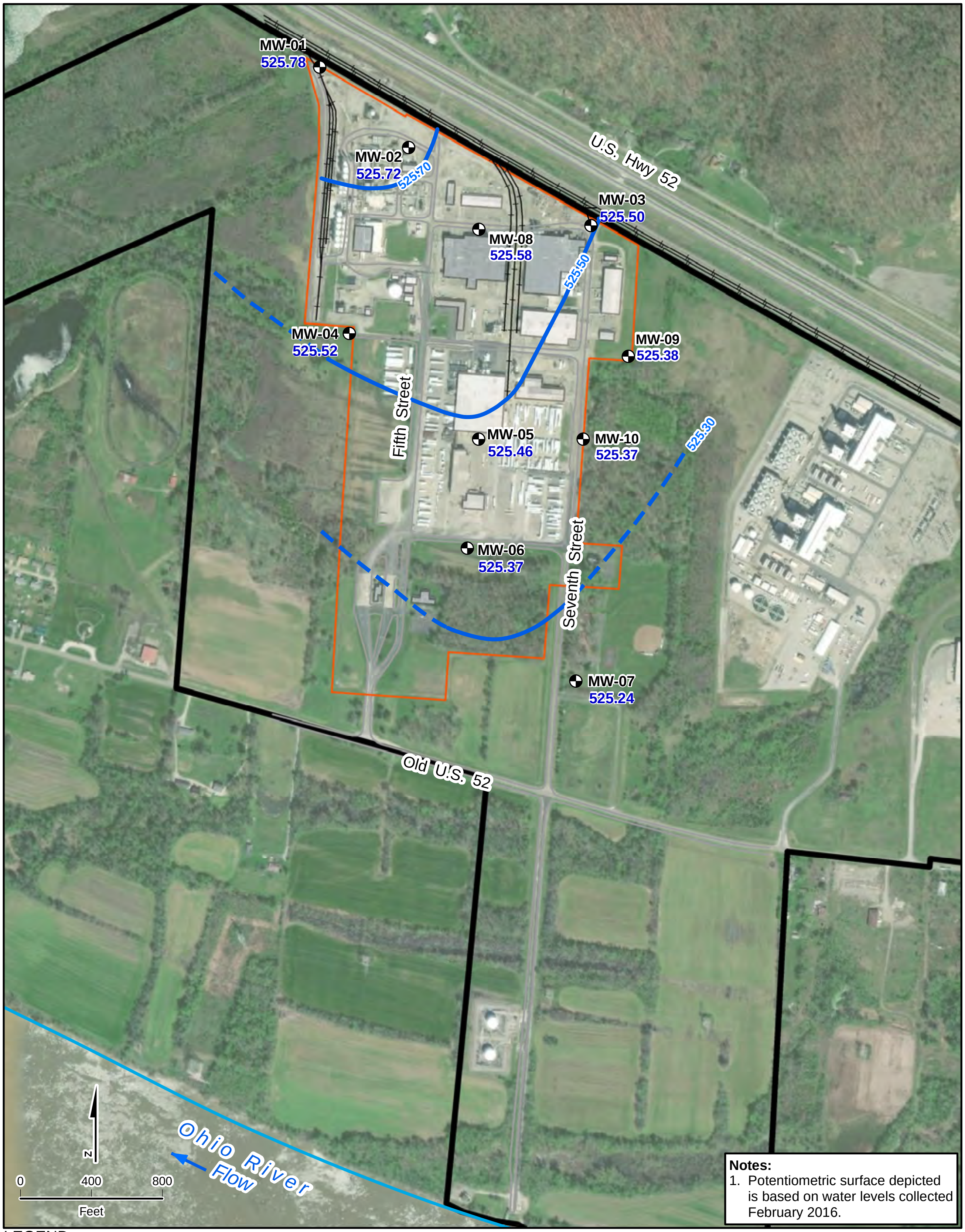


Figure 2-5
Cross Section A - A'
Dow Hanging Rock Phase 3 RFI Report
Ironton, Ohio

JACOBS



LEGEND

- Approximate Facility Boundary
- Railroad
- Fence
- Edge of Road
- Building
- Monitoring Well
- River
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour Outside the Area of Data

FIGURE 2-6

Potentiometric Surface Map (2016)

Dow Hanging Rock Corrective Measures Proposal

Ironton, Ohio

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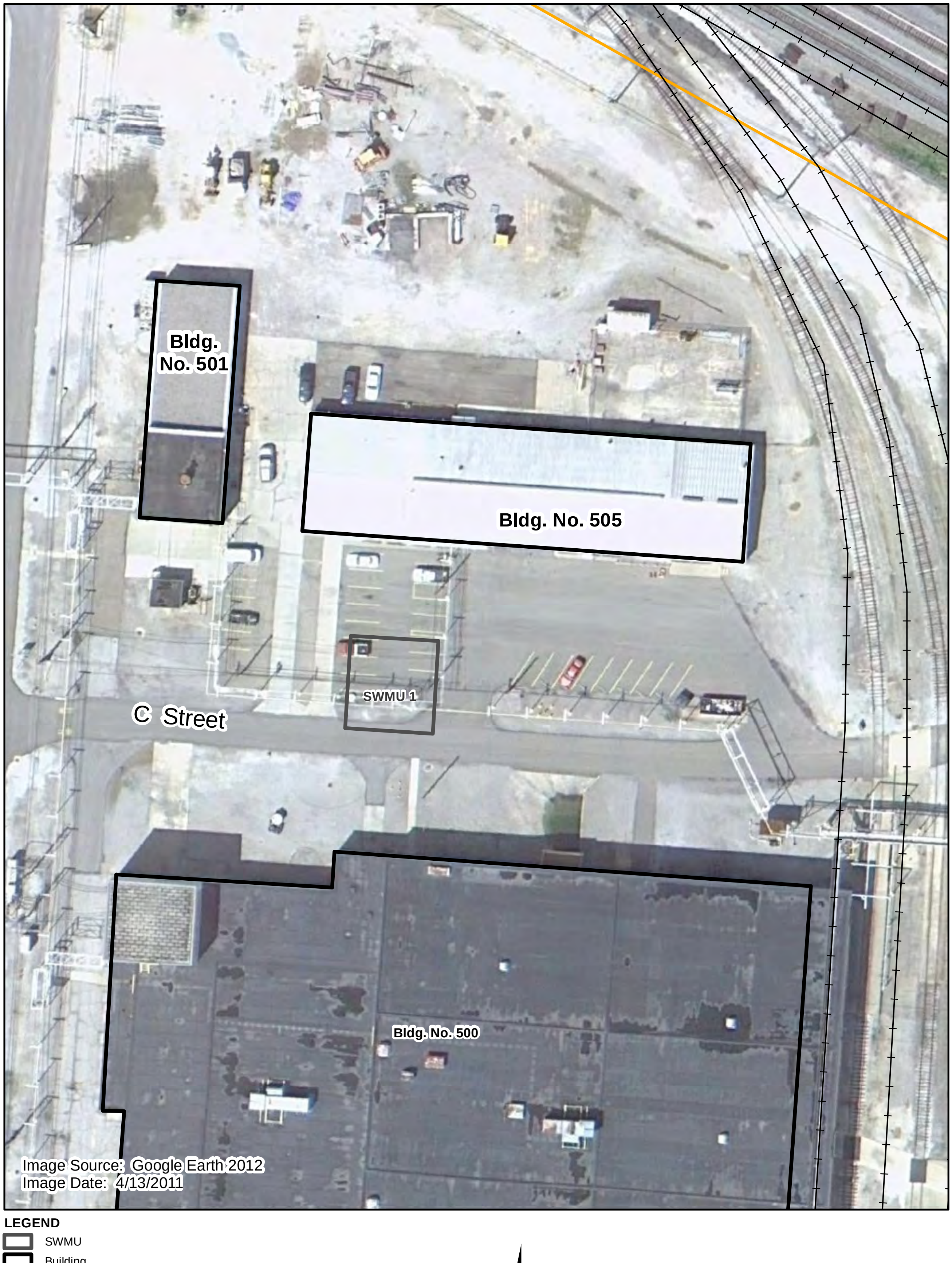
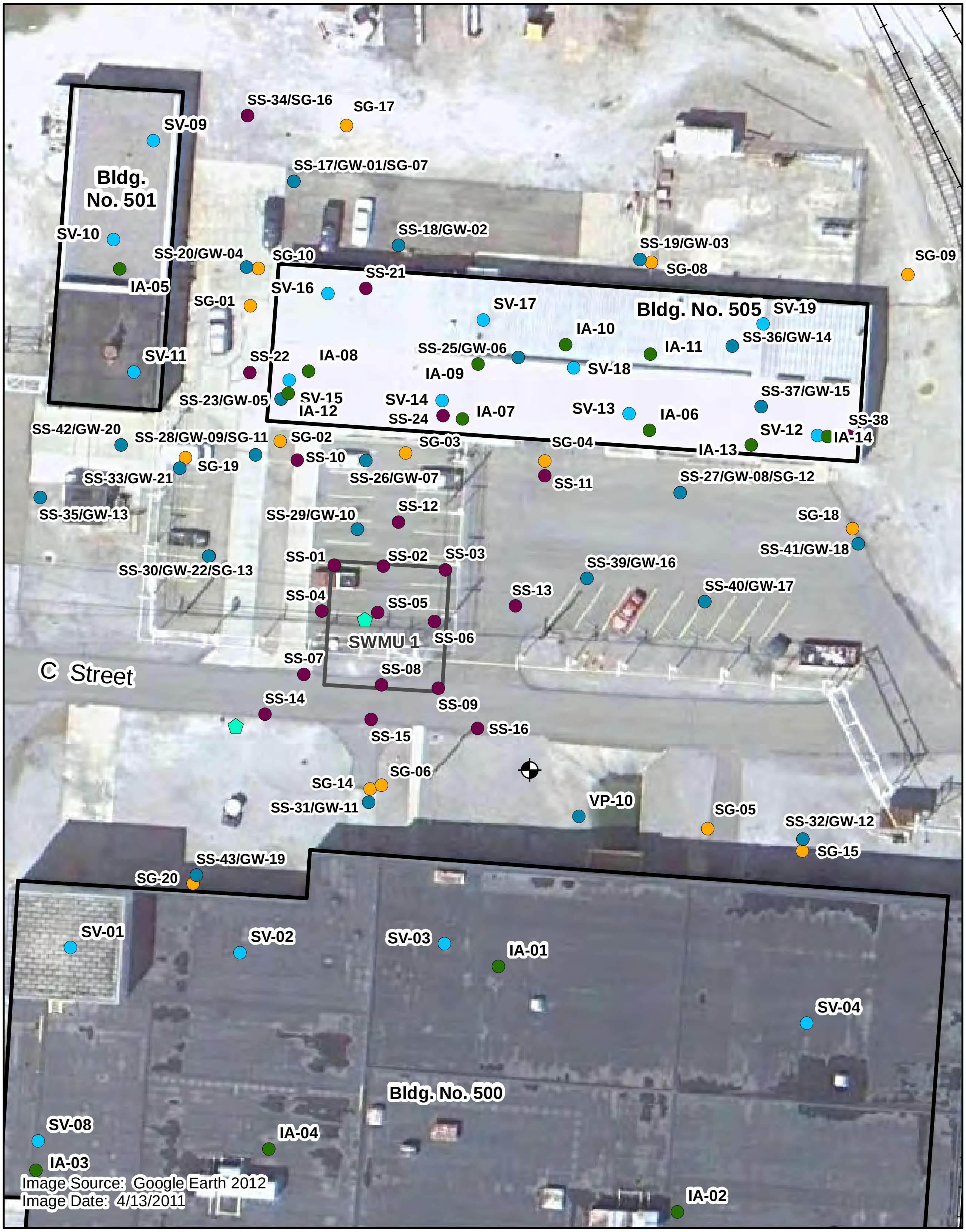


FIGURE 2-7
SWMU 1 Area Location Map
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

JACOBS

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Working_JW\Fig2-6_SWMU1_Area_Location_Map.mxd



LEGEND

- Monitoring Well Location
- Soil Gas Sample Location
- Manhole/Sewer Gas Sample Location
- Groundwater Grab Sample Location
- Soil Sample Location
- Indoor Air Sample
- Subslab Soil Gas Sample Location
- Building
- SWMU

N

0 27.5 55

Feet

FIGURE 2-8
Focused SWMU 1
Sample Locations
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

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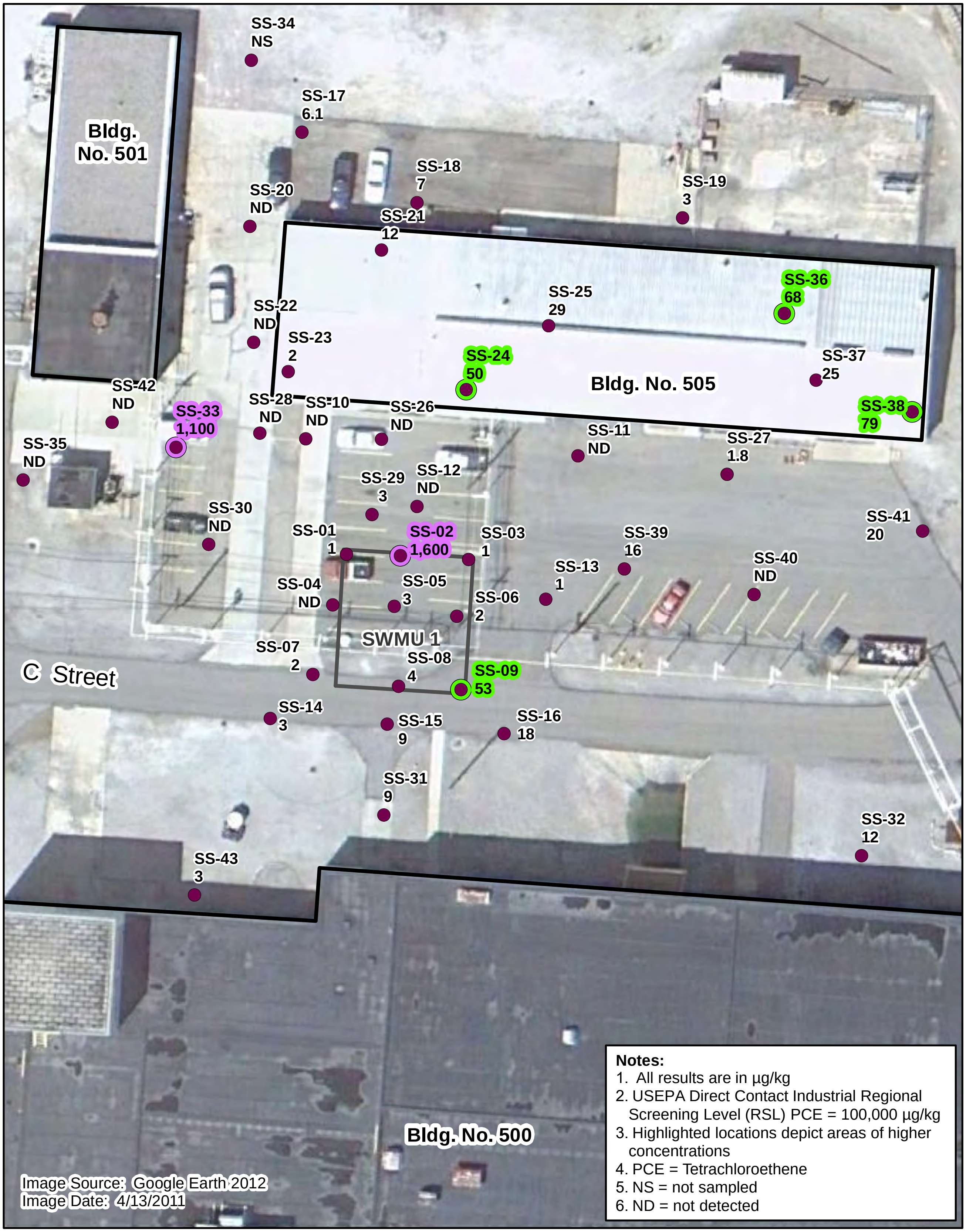
\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Corrective_Measures_Proposal\Fig2-2_Sample_Locations_20190918.mxd



LEGEND

- Soil Sample Location
- Locations highlighted green have detected concentrations between 50 µg/kg and 100 µg/kg
- Locations highlighted purple have detected concentrations above 1,000 µg/kg
- Building
- SWMU

N

0 25 50
Feet

FIGURE 2-9
SWMU 1 Soil PCE Results, 0 to 2 Feet
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

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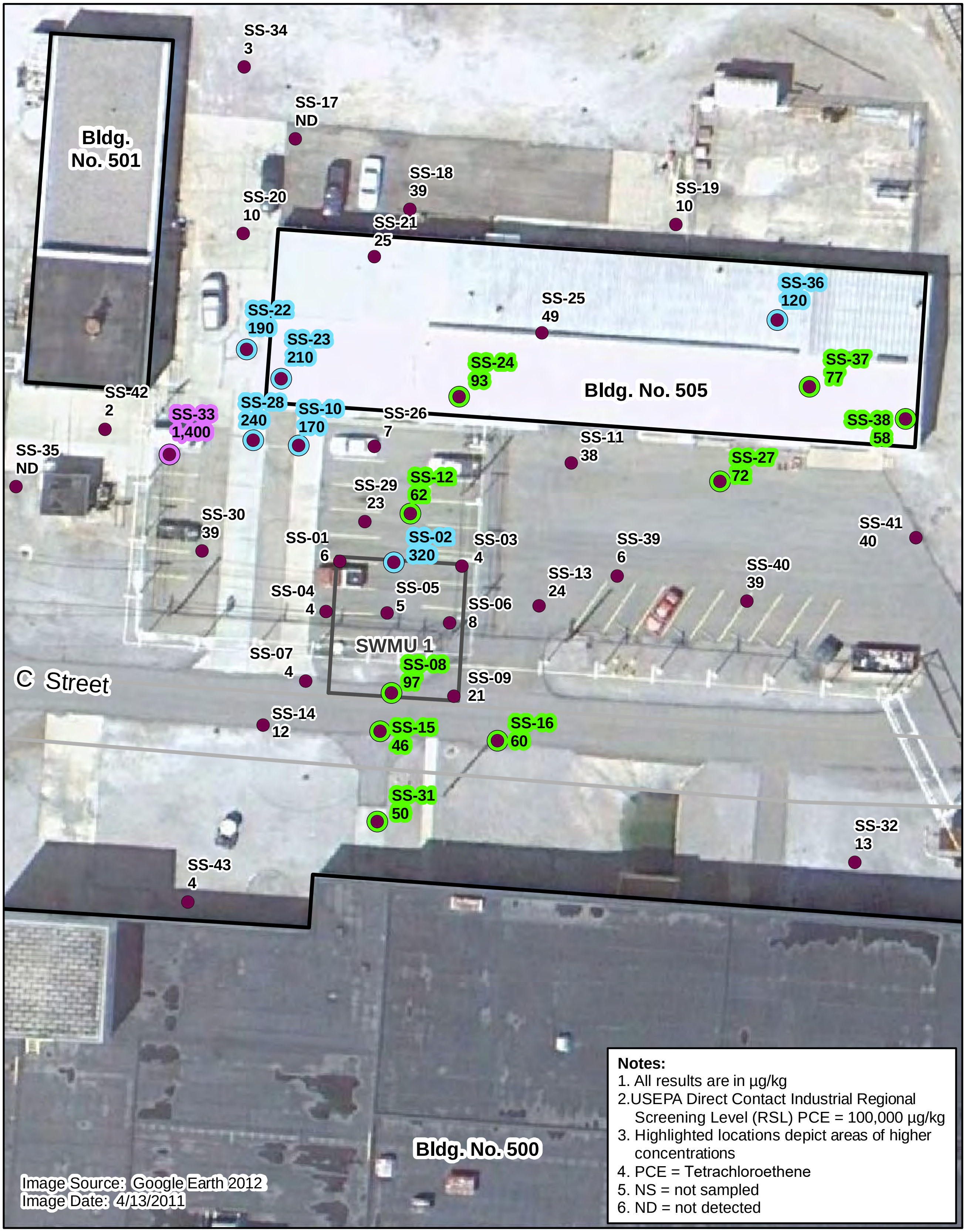
\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Phase_3_Report\Fig4-4_Soil_Sample_0to2_Results_PCE.mxd



LEGEND

- Soil Sample Location
- Locations highlighted green have detected concentrations between 50 µg/kg and 99 µg/kg
- Locations highlighted green have detected concentrations between 100 µg/kg and 999 µg/kg
- Locations highlighted green have detected concentrations above 1000 µg/kg
- Edge of Road
- Building
- SWMU

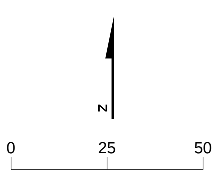


FIGURE 2-10
SWMU 1 Soil PCE Results, 5 to 10 Feet

Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

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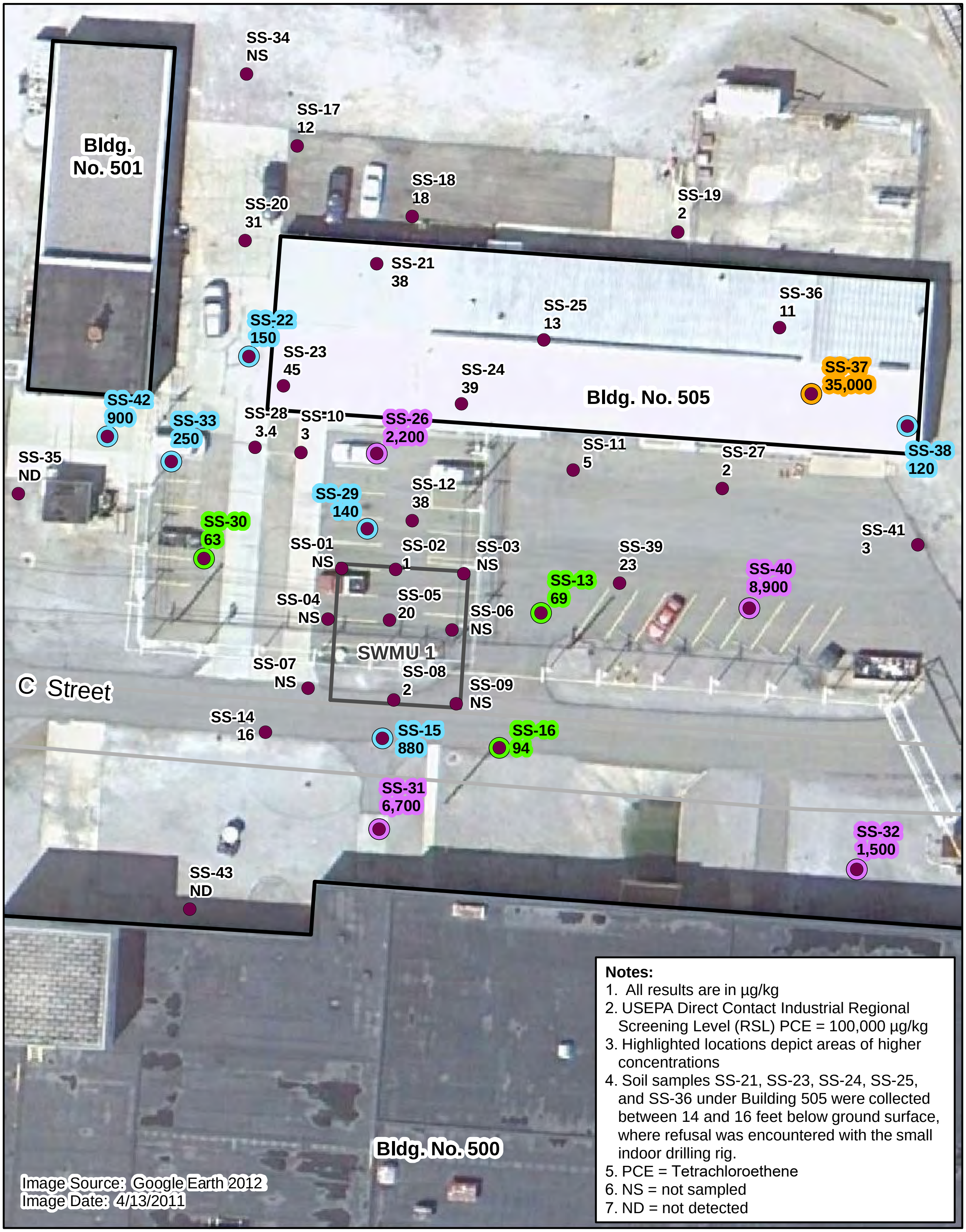
\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Phase_3_Report\Fig4-6_Soil_Sample_6to10_Results_PCE.mxd



Notes:

1. All results are in µg/kg
2. USEPA Direct Contact Industrial Regional Screening Level (RSL) PCE = 100,000 µg/kg
3. Highlighted locations depict areas of higher concentrations
4. Soil samples SS-21, SS-23, SS-24, SS-25, and SS-36 under Building 505 were collected between 14 and 16 feet below ground surface, where refusal was encountered with the small indoor drilling rig.
5. PCE = Tetrachloroethene
6. NS = not sampled
7. ND = not detected

LEGEND

- Soil Sample Location
- Locations highlighted green have detected concentrations between 50 µg/kg and 99 µg/kg
- Locations highlighted green have detected concentrations between 100 µg/kg and 999 µg/kg
- Locations highlighted green have detected concentrations between 1,000 µg/kg and 9,999
- Locations highlighted green have detected concentrations at 35,000 µg/kg
- Edge of Road
- Building
- SWMU

N

0 25 50
Feet

FIGURE 2-11
SWMU 1 Soil PCE Results, 21 to 29 Feet
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

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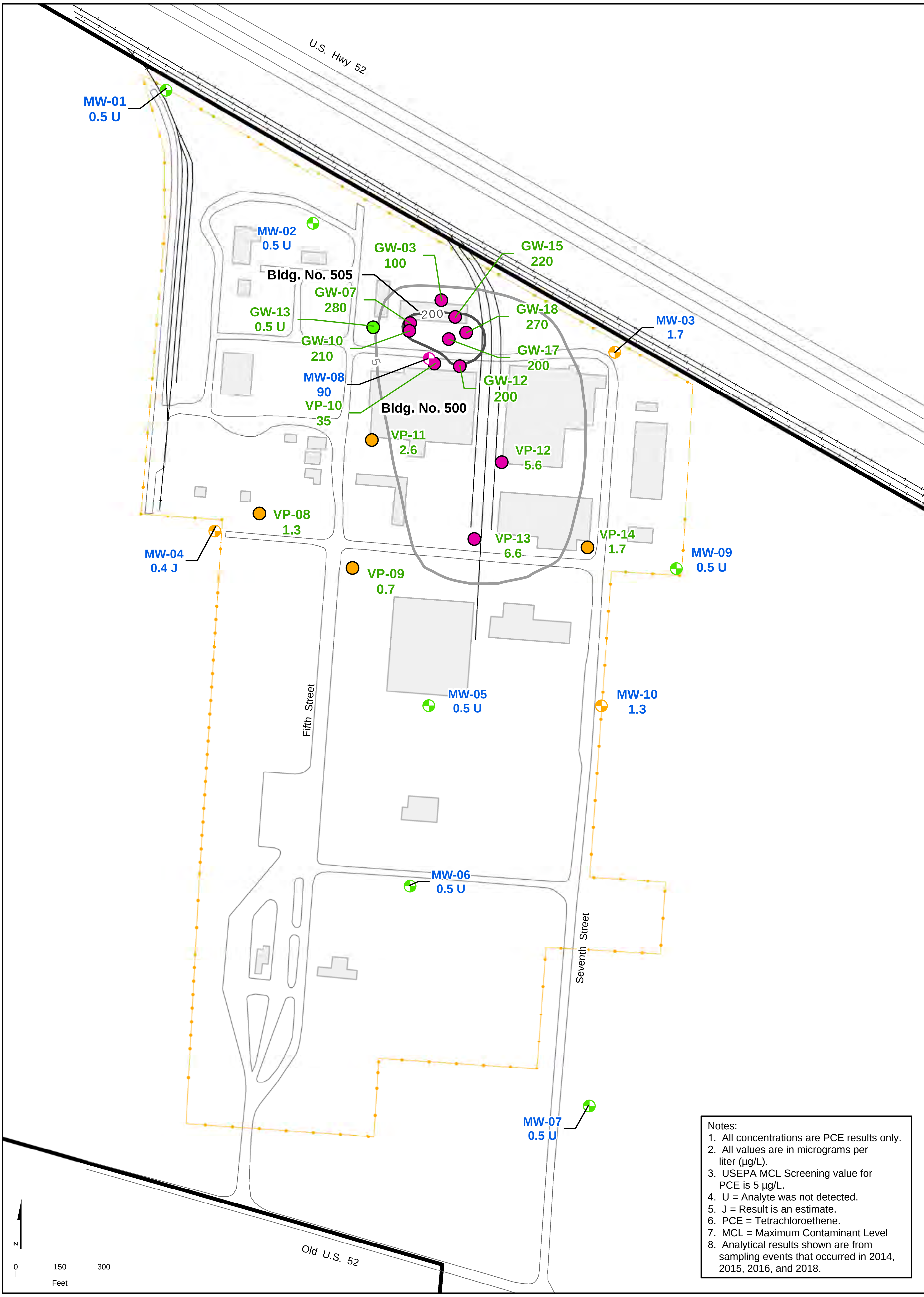
\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Phase_3_Report\Fig4-8_Soil_Sample_21to29_Results_PCE.mxd



Notes:
1. All concentrations are PCE results only.
2. All values are in micrograms per liter (µg/L).
3. USEPA MCL Screening value for PCE is 5 µg/L.
4. U = Analyte was not detected.
5. J = Result is an estimate.
6. PCE = Tetrachloroethene.
7. MCL = Maximum Contaminant Level
8. Analytical results shown are from sampling events that occurred in 2014, 2015, 2016, and 2018.

LEGEND

- Approximate Facility Boundary
- Building
- Railroad
- Fence
- Edge of Road
- Groundwater Grab Location with No Detections
- Groundwater Grab Location with Detections Below MCLs
- Groundwater Grab Location with Detections Above MCLs
- Monitoring Well with No Detections
- Monitoring Well with Detections Below MCLs
- Monitoring Well with Detections Above MCLs

Tetrachloroethene Values

- 5 µg/L
- 200 µg/L

FIGURE 2-12
Facility Groundwater Results (PCE)
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

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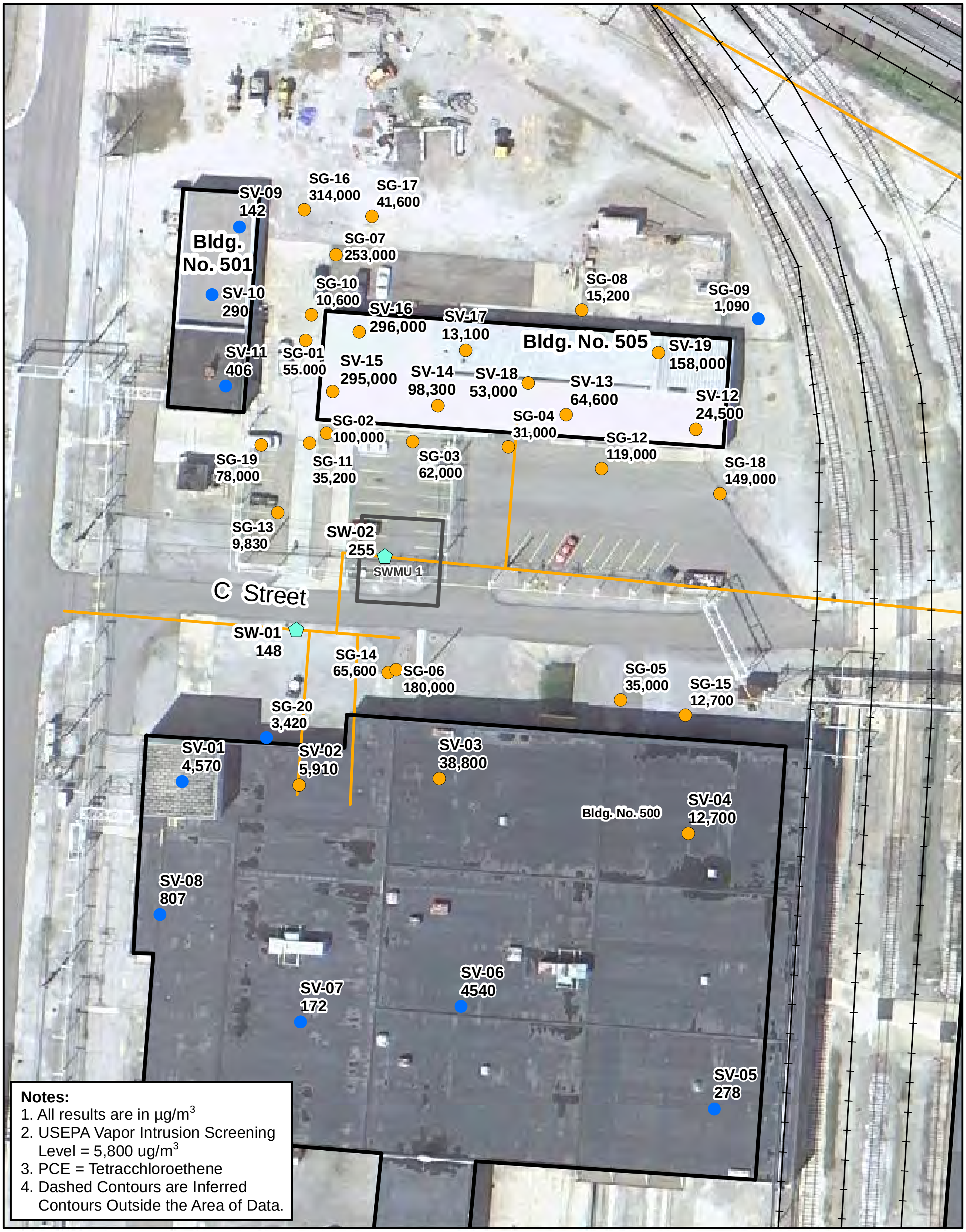


Notes:
1. All results are in µg/m^3
2. USEPA Vapor Intrusion Screening Level = 5,800 ug/m^3
3. PCE = Tetracchloroethene
4. Dashed Contours are Inferred Contours Outside the Area of Data.

LEGEND
- Soil Gas Sample Location
- Soil Gas Sample Exceeds VISL
- Manhole/Sewer Gas Location
- Sanitary Sewer Line
- Building
- SWMU

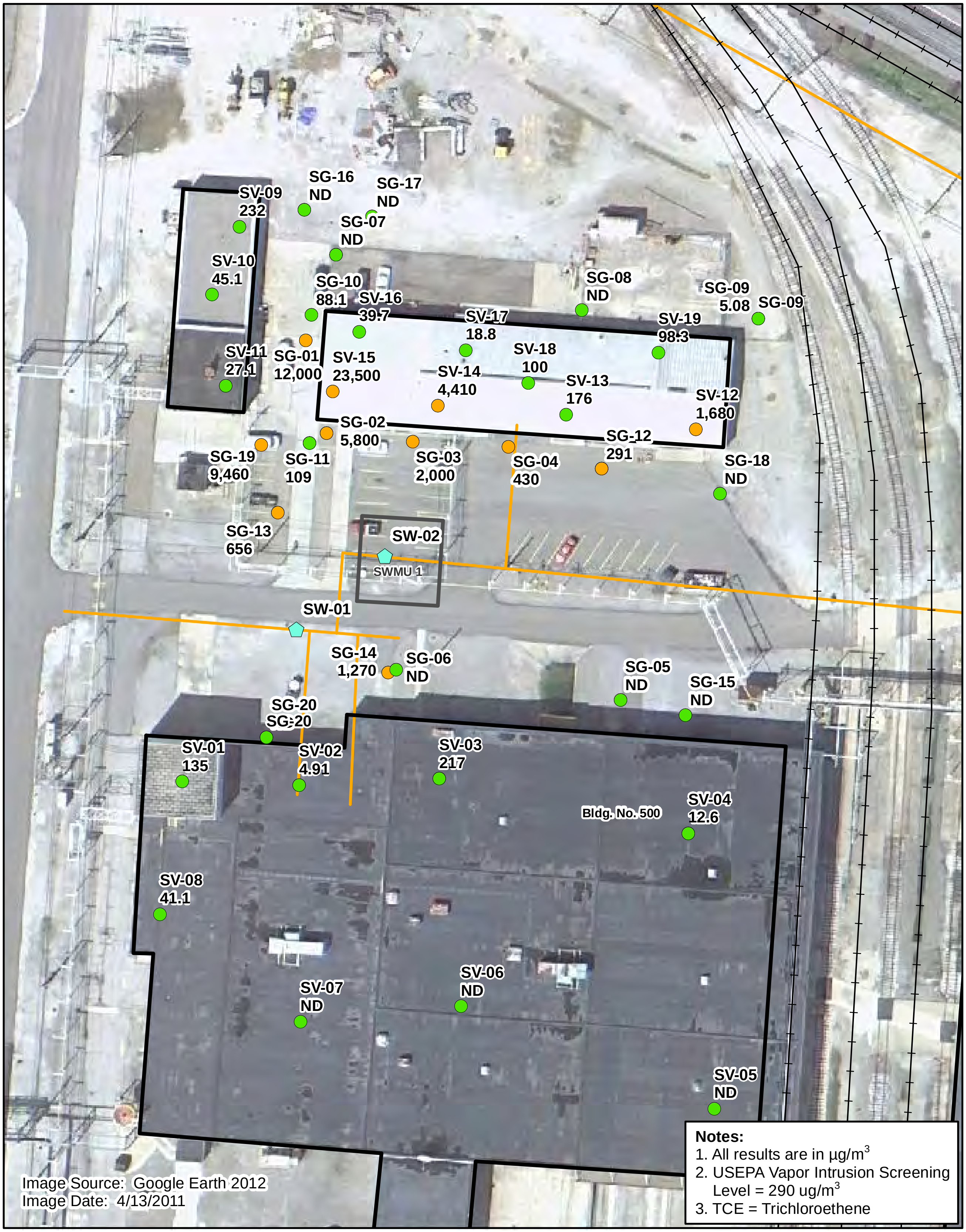
N

0 25 50
Feet

FIGURE 2-13
SWMU 1 Soil Gas PCE Results
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

JACOBS

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Working_JW\Fig2-10_SWMU1_Soil_Gas_PCE_Results.mxd



LEGEND

- Soil Gas Sample Location
- Soil Gas Sample Exceeds VISL
- Manhole/Sewer Gas Location
- Sanitary Sewer Line
- Building
- SWMU

N

0 25 50
Feet

Figure 2-14
SWMU 1 Soil Gas TCE Results
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Working_JW\Fig2-11_SWMU1_Soil_Gas_TCE_Results.mxd

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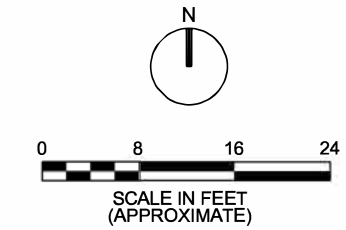
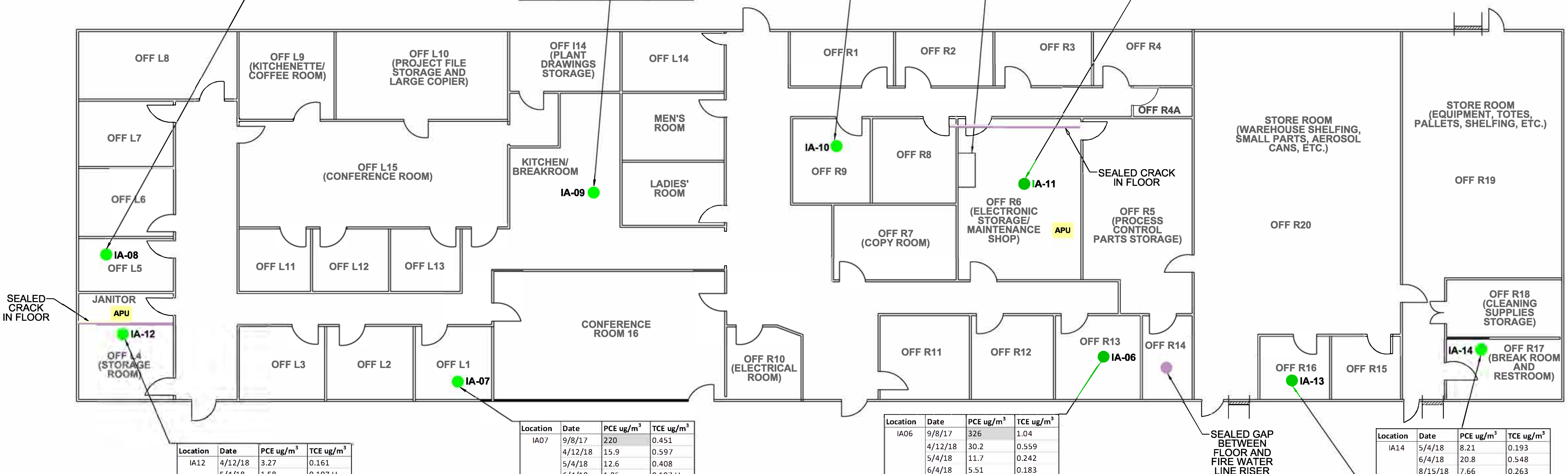


Location	Date	PCE ug/m^3	TCE ug/m^3
IA08	9/8/17	197	0.403
	5/4/18	6.64	0.220
	6/4/18	1.72	0.107 U
	8/15/18	2.21	0.204
	12/7/18	2.86	0.145

Location	Date	PCE ug/m^3	TCE ug/m^3
IA09	9/8/17	268	0.543
	4/12/18	17.4	0.532
	5/4/18	8.41	0.290
	6/4/18	3.39	0.140
	8/15/18	1.67	0.129
	12/7/18	3.33	0.113

Location	Date	PCE ug/m^3	TCE ug/m^3
IA10	9/8/17	324	1.000
	4/12/18	45.5	0.736
	5/4/18	14.6	0.575
	6/4/18	3.42	0.145
	8/15/18	1.79	0.145
	12/7/18	5.61	0.204

Location	Date	PCE ug/m^3	TCE ug/m^3
IA11	4/12/18	30.6	0.376
	5/4/18	9.56	0.220
	6/4/18	3.40	0.118
	8/15/18	1.59	0.107 U
	12/7/18	6.32	0.156



Location	Date	PCE ug/m^3	TCE ug/m^3
IA12	4/12/18	3.27	0.161
	5/4/18	1.58	0.107 U
	6/4/18	1.11	0.107 U
	8/15/18	1.08	0.193
	12/7/18	3.01	0.150

Location	Date	PCE ug/m^3	TCE ug/m^3
IA07	9/8/17	220	0.451
	4/12/18	15.9	0.597
	5/4/18	12.6	0.408
	6/4/18	1.85	0.107 U
	8/15/18	1.55	0.150
	12/7/18	5.35	0.145

Location	Date	PCE ug/m^3	TCE ug/m^3
IA06	9/8/17	326	1.04
	4/12/18	30.2	0.559
	5/4/18	11.7	0.242
	6/4/18	5.51	0.183
	8/15/18	1.99	0.124
	12/7/18	0.163	0.107 U

Location	Date	PCE ug/m^3	TCE ug/m^3
IA14	5/4/18	8.21	0.193
	6/4/18	20.8	0.548
	8/15/18	7.66	0.263
	12/7/18	4.35	0.118

Location	Date	PCE ug/m^3	TCE ug/m^3
IA13	5/4/18	19.0	0.177
	6/4/18	15.2	0.333
	8/15/18	12	0.242
	12/7/18	19.7	0.430

Location	Date	PCE ug/m^3	TCE ug/m^3
Outdoor Air	9/8/17	0.068 J	0.107 U
	4/12/18	0.136 U	0.107 U
	5/4/18	0.156	0.107 U
	6/4/18	0.136 U	0.107 U
	8/15/18	0.136 U	0.107 U
	12/7/18	3.38	0.118

Analyte	Unit	Ohio EPA Response Action Level	USEPA Regional Screening Level
Tetrachloroethylene (PCE)	µg/m³	180	175
Trichloroethylene (TCE)	µg/m³	8.8	9

Legend

APU AIR PURIFYING UNIT

INDOOR AIR SAMPLE

GARAGE DOOR

Notes:

µg/m³ = MICROGRAMS PER CUBIC METER

SHADED DATA EXCEEDS THE SCREENING LEVEL

U = NOT DETECTED

Figure 2-15

SWMU 1 Indoor Air PCE and TCE Analytical Results

Hanging Rock Corrective Measures Proposal
Ironton, OH

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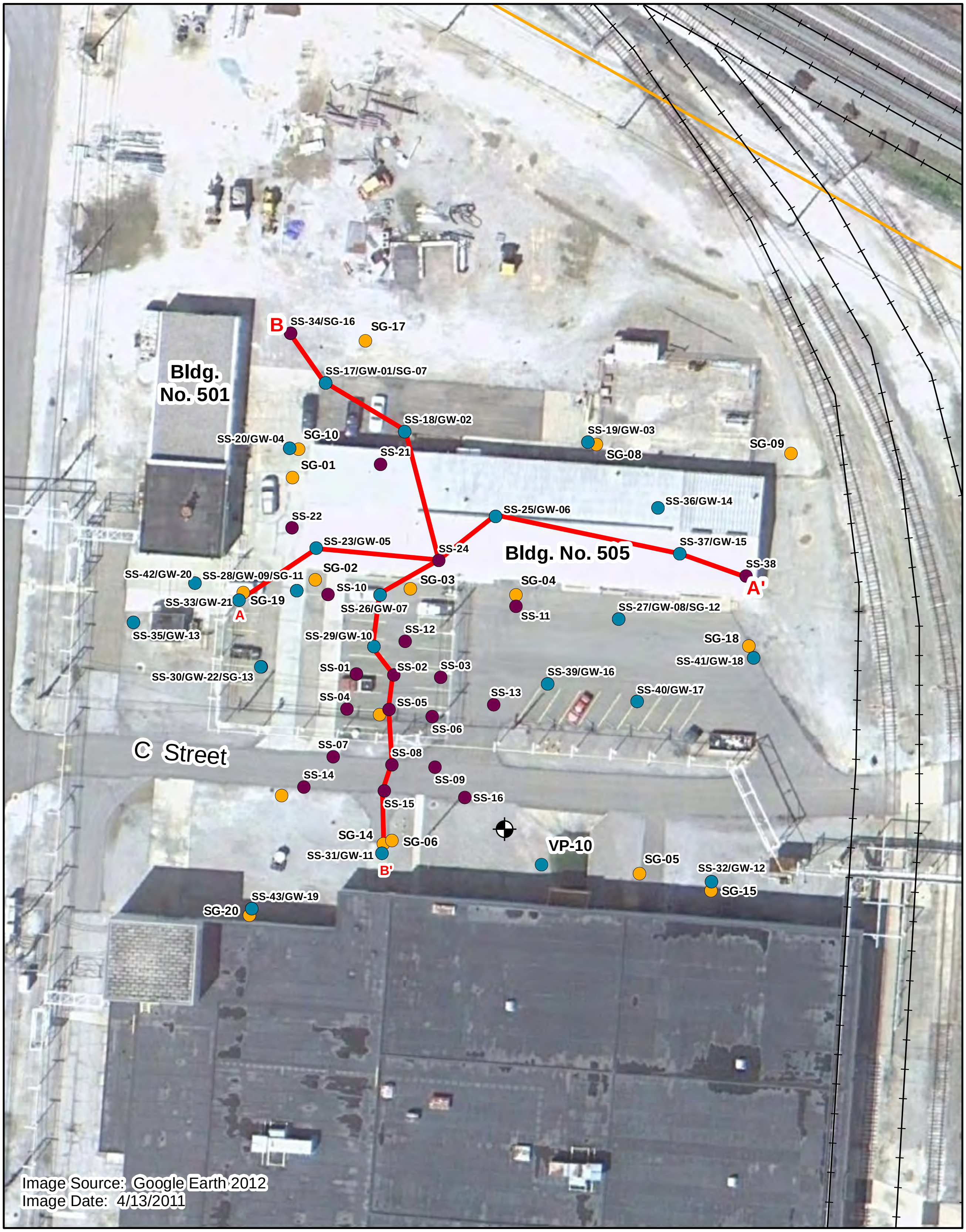
PW | DEN001 | DOCUMENTS - DEN1 WBG IMPERIAL SF | DESIGNS - SMALL PROJECTS | 693874 - DOW HANGING ROCK | DLV | F11_693874.dgn



LEGEND

- Monitoring Well Location
- Groundwater Grab Sample Location
- Soil Sample Location
- Soil Gas Sample Location
- Cross Section Location

N

0 27.5 55

Feet

FIGURE 3-1
Target Treatment Area Cross Section Locations

Dow Hanging Rock Corrective Measures Proposal

Ironton, Ohio

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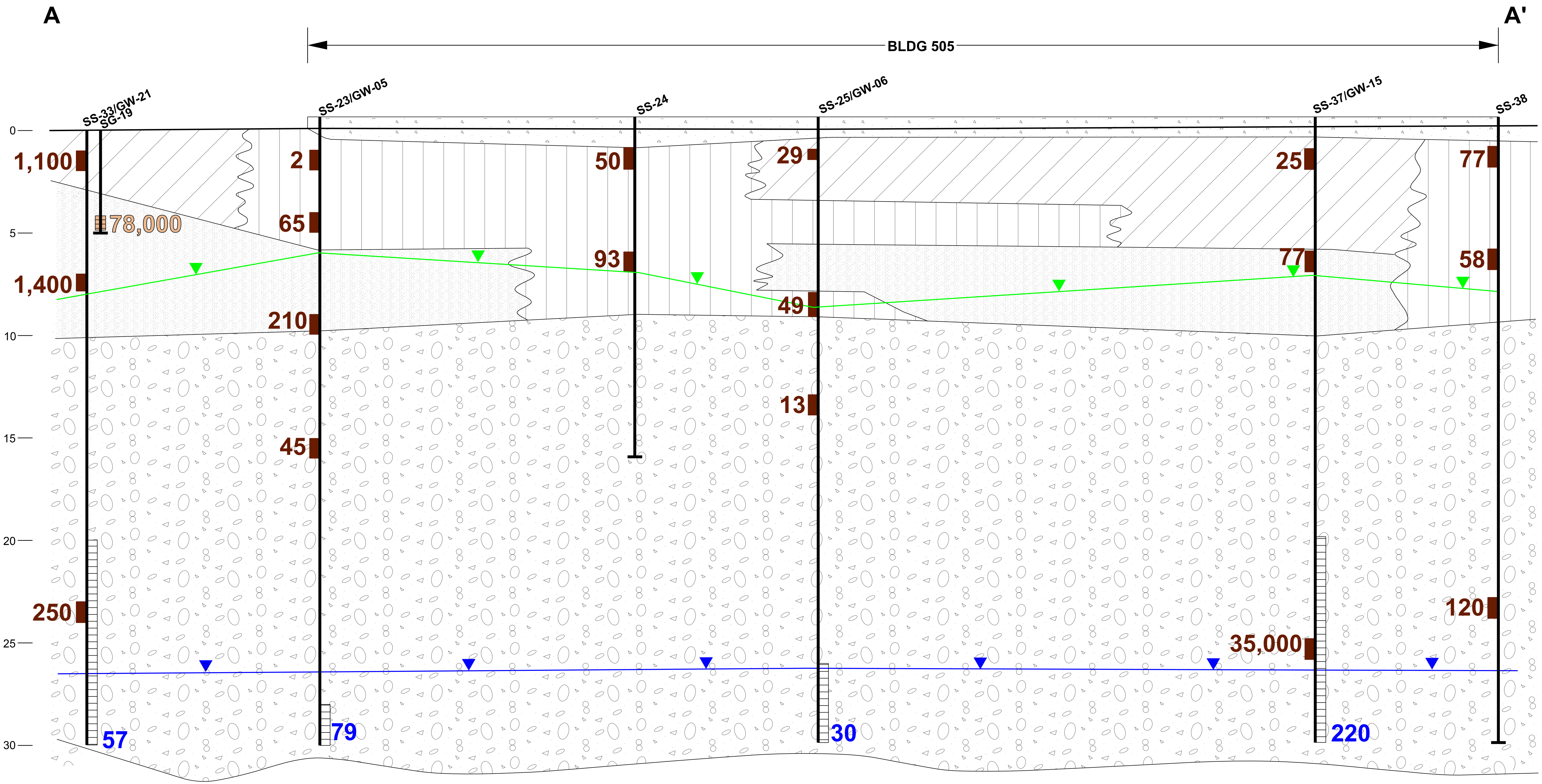
\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Corrective_Measures_Proposal\Fig3-1_Cross_Section_Locations_20190918.mxd



LEGEND

CLAY
SILT AND FINE SAND
SAND
SANDY GRAVEL
CONCRETE
PERCHED SATURATED ZONE
APPROX. WATER TABLE
SOIL GAS SAMPLE SCREEN
SOIL SAMPLE INTERVAL
GROUNDWATER SAMPLE INTERVAL (TEMPORARY SCREEN)
78,000 SOIL GAS SAMPLE µg/m³
250 SOIL SAMPLE PCE µg/kg
57 GROUNDWATER SAMPLE PCE µg/L

Figure 3-2
Vertical Profile PCE Results
Cross-Section A - A'
Dow Hanging Rock Phase 3 RFI Report
Ironton, Ohio

JACOBS

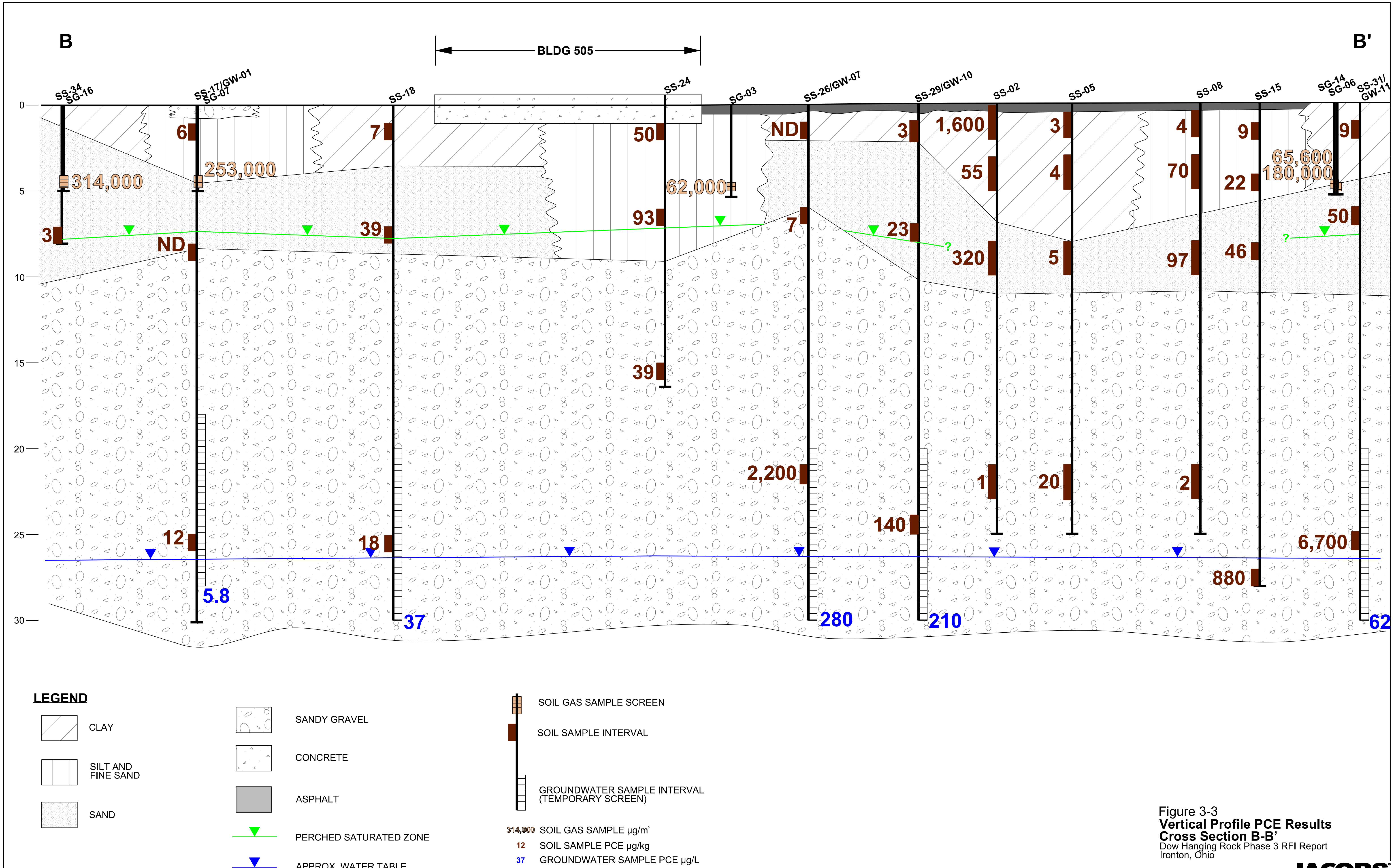
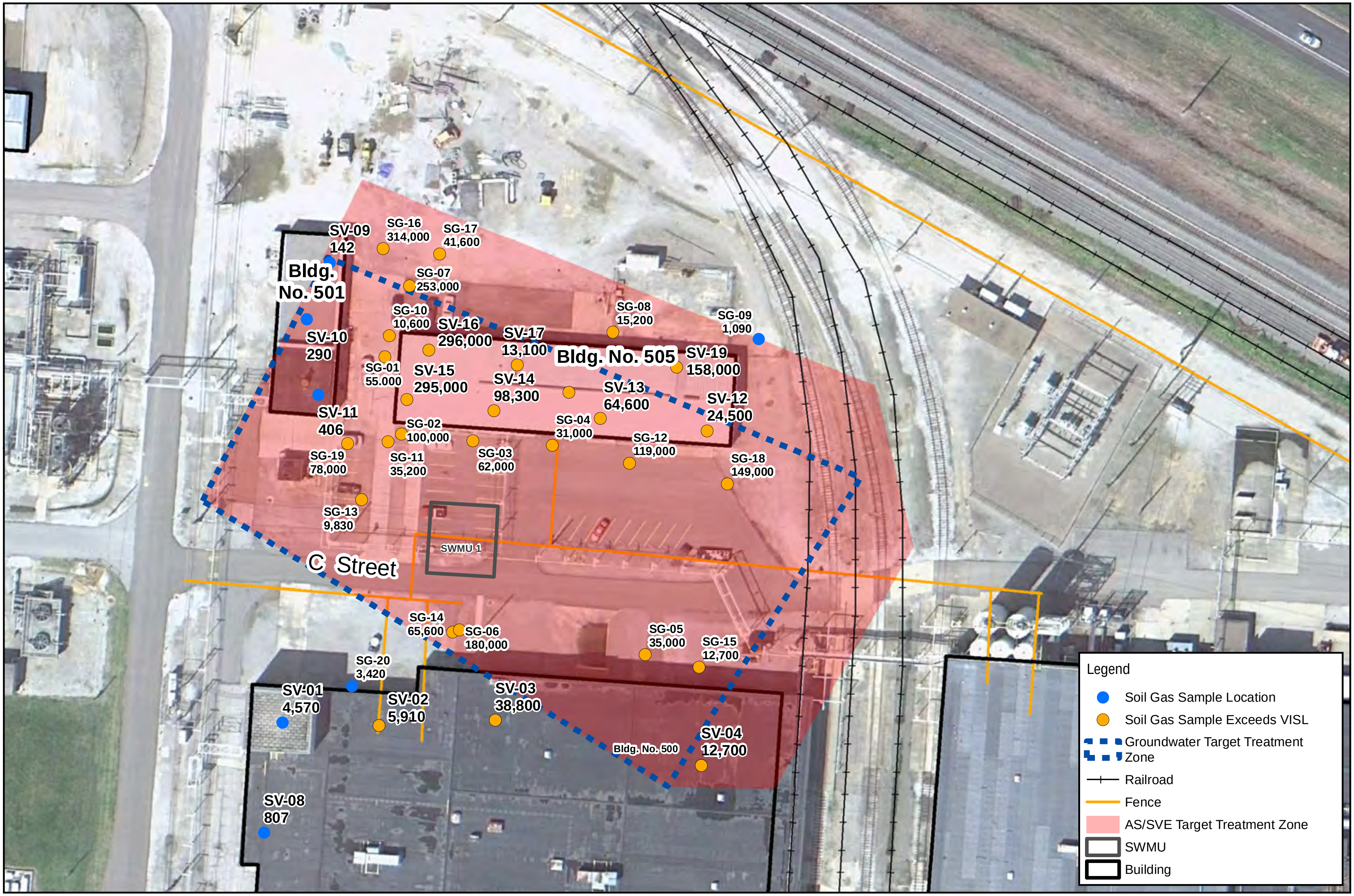


Figure 3-3
Vertical Profile PCE Results
Cross Section B-B'
Dow Hanging Rock Phase 3 RFI Report
Ironton, Ohio

JACOBS



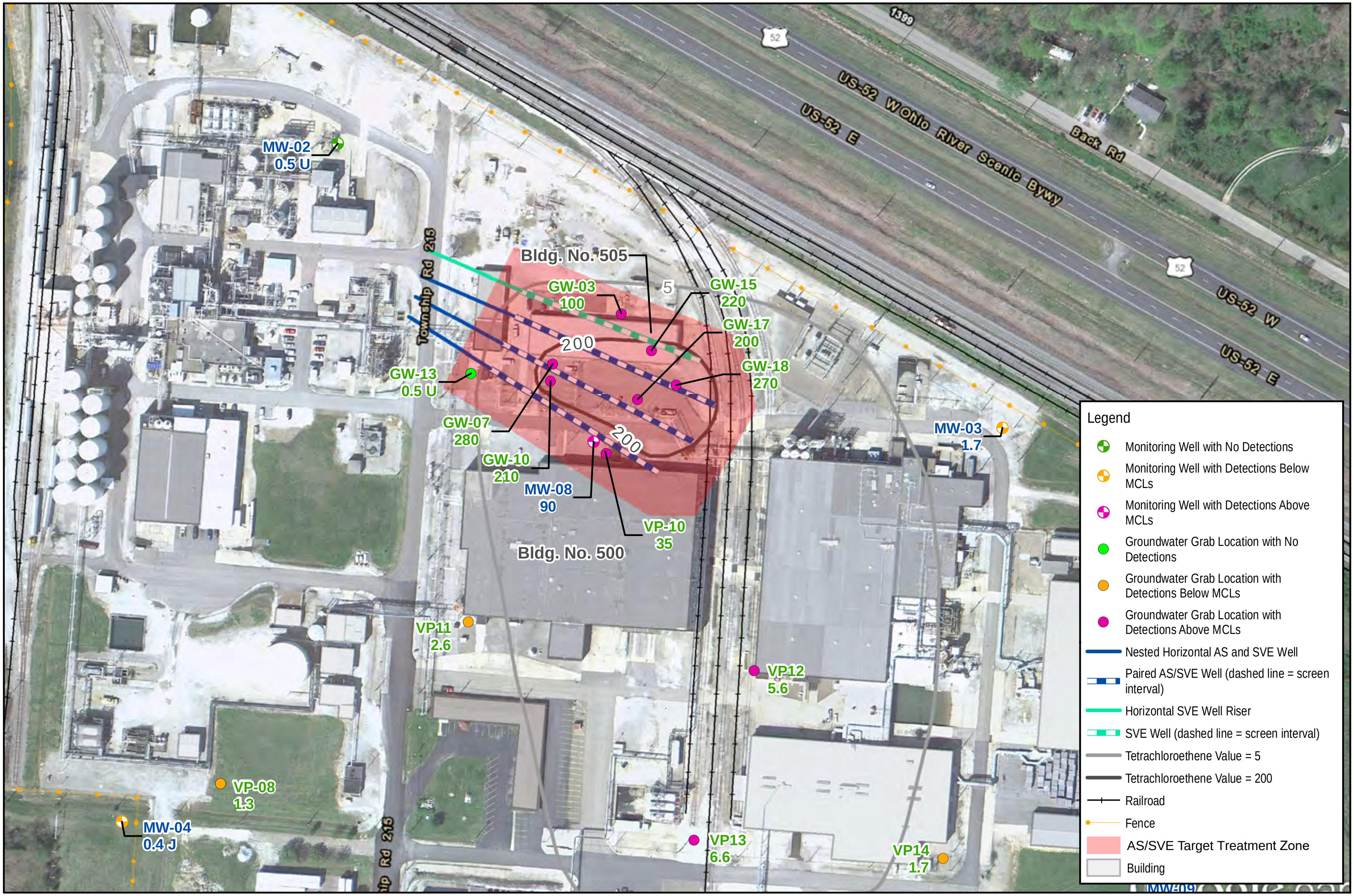
Notes:
1. Soil PCE Results from 21 to 29 feet
2. All results are in µg/kg
3. USEPA Direct Contact Industrial Regional Screening Level (RSL) PCE = 100,000 µg/kg
4. Highlighted locations depict areas of higher concentrations
5. Soil samples SS-21, SS-23, SS-24, SS-25, and SS-36 under Building 505 were collected between 14 and 16 feet below ground surface, where refusal was encountered with the small indoor drilling rig.
6. PCE = Tetrachloroethene
7. NS = not sampled
8. ND = not detected

Base Map Source:
Image Source: Google Earth 2012
Image Date: 4/13/2011

Figure 3-4
Target Treatment Soil Gas and Groundwater Zones
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\D\DOW_CHEMICAL\DOW_HANGING_ROCK_404798\MAPFILES\WORKING_JW\FIGURE 3-4 TARGET TREATMENT SOIL GAS AND GROUNDWATER ZONES.MXD WOODSJ2 12/5/2019

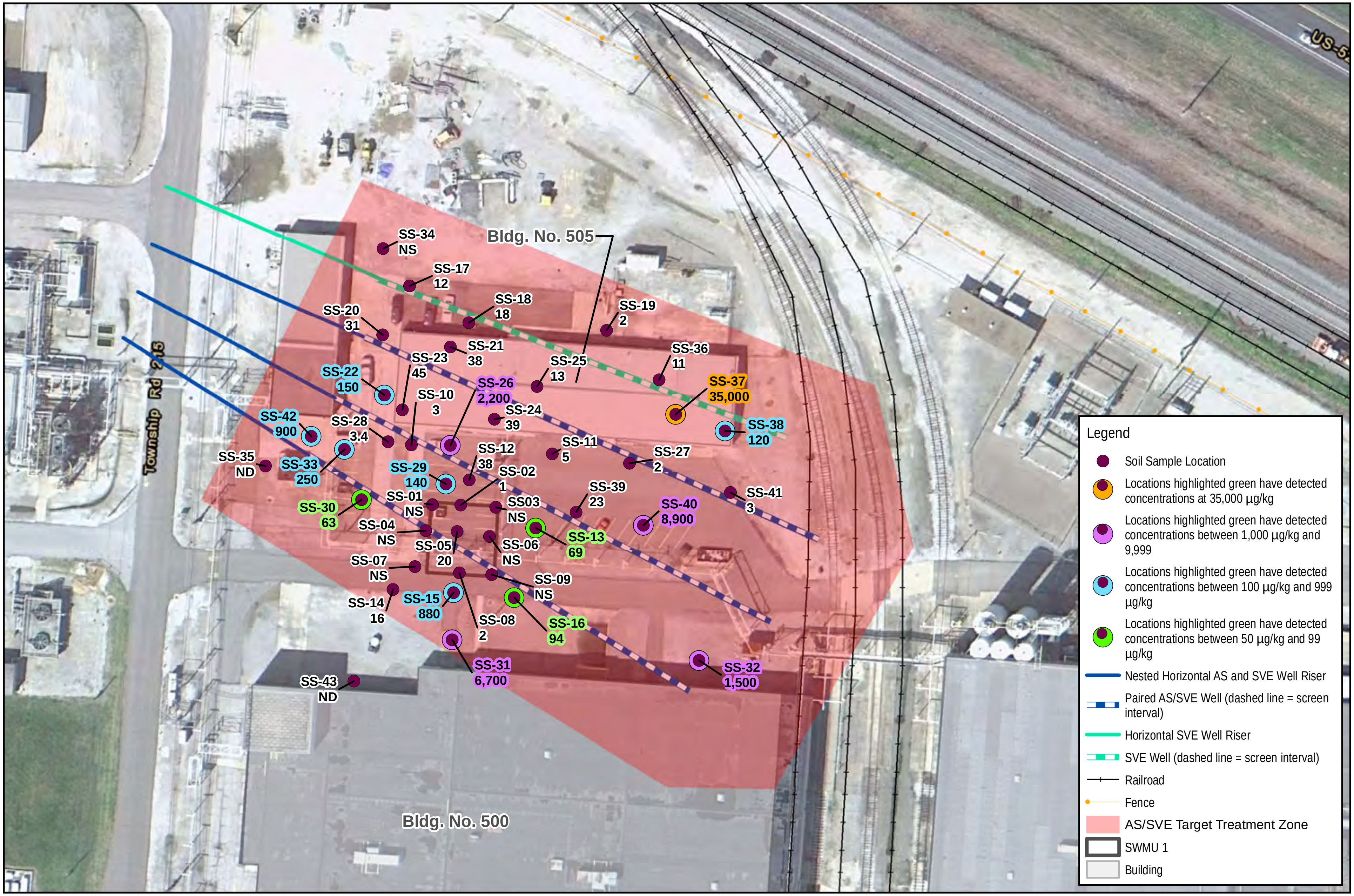
JACOBS



Notes:
1. All concentrations are PCE results only.
2. All values are in micrograms per liter (µg/L).
3. USEPA MCL Screening value for PCE is 5 µg/L.
4. U = Analyte was not detected.
5. J = Result is an estimate.
6. PCE = Tetrachloroethene.
7. MCL = Maximum Contaminant Level
8. Analytical results shown are from sampling events that occurred in 2014, 2015, 2016, and 2018.
9. AS well depth: 50 ft bgs
   SVE well depth: 18 ft bgs
10. ft bgs = feet below ground surface

Base Map Source:
Image Source: Google Earth 2012
Image Date: 4/13/2011

Figure 4-1a
Conceptual AS/SVE with Horizontal Wells
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio



Notes:
1. Soil PCE Results from 21 to 29 feet
2. All results are in µg/kg
3. USEPA Direct Contact Industrial Regional Screening Level (RSL) PCE = 100,000 µg/kg
4. Highlighted locations depict areas of higher concentrations
5. Soil samples SS-21, SS-23, SS-24, SS-25, and SS-36 under Building 505 were collected between 14 and 16 feet below ground surface, where refusal was encountered with the small indoor drilling rig.
6. PCE = Tetrachloroethene
7. NS = not sampled
8. ND = not detected

Base Map Source:
Image Source: Google Earth 2012
Image Date: 4/13/2011

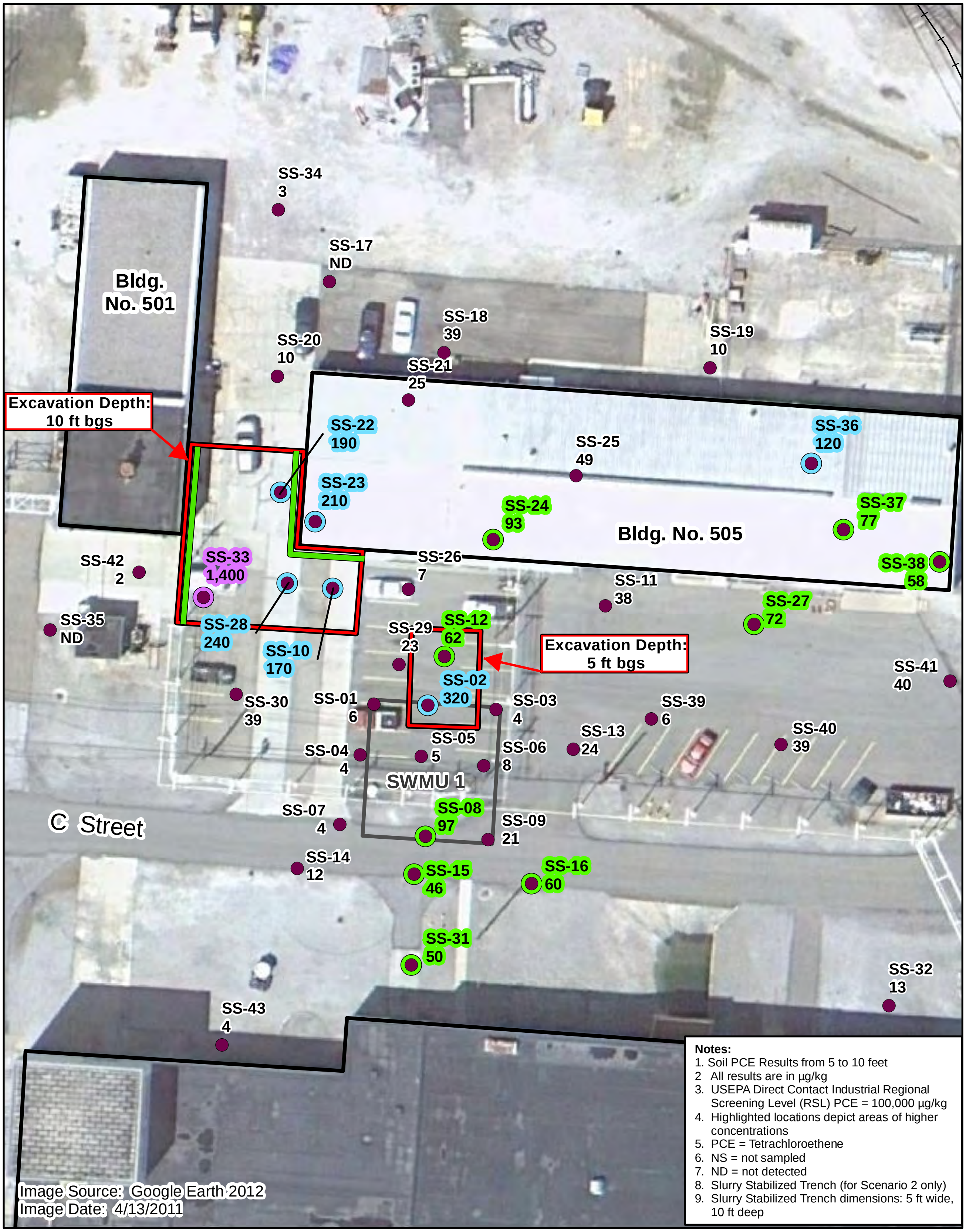
N

0 90 180
Approximate scale in feet

Figure 4-1b
Conceptual AS/SVE with Horizontal Wells
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\D\DOW_CHEMICAL\DOW_HANGING_ROCK_404798\MAPFILES\CORRECTIVE_MEASURES_PLAN\FIG1-2B_AS_SVE_WHORIZONTAL_WELLS_20191118.MXD WOODSJ2 11/22/2019

JACOBS



Notes:
1. Soil PCE Results from 5 to 10 feet
2. All results are in µg/kg
3. USEPA Direct Contact Industrial Regional Screening Level (RSL) PCE = 100,000 µg/kg
4. Highlighted locations depict areas of higher concentrations
5. PCE = Tetrachloroethene
6. NS = not sampled
7. ND = not detected
8. Slurry Stabilized Trench (for Scenario 2 only)
9. Slurry Stabilized Trench dimensions: 5 ft wide, 10 ft deep

LEGEND

- Soil Sample Location
- Locations highlighted green have detected concentrations between 50 µg/kg and 99 µg/kg
- Locations highlighted green have detected concentrations between 100 µg/kg and 999 µg/kg
- Locations highlighted green have detected concentrations above 1000 µg/kg
- Building
- SWMU
- Extent of Excavation
- Slurry-Stabilized Trench

N

0 25 50
Feet

Figure 4-2
Conceptual Shallow Excavation Extent
Dow Hanging Rock - Corrective Measures Plan
Ironton, Ohio

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\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Working_JW\Figure3-2_Proposed_Excavation_Extent.mxd

(For Scenario 2 Only)

LEGEND

- Monitoring Well Location
- Groundwater Grab Sample Location
- Soil Sample Location
- Soil Gas Sample Location
- Cross Section Location
- Building
- Conceptual Thermal Treatment

N

0 27.5 55
Feet

FIGURE 4-3
Conceptual Thermal Treatment Areas
Dow Hanging Rock Corrective Measures Proposal
Ironton, Ohio

JACOBS

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\D\Dow_Chemical\Dow_Hanging_Rock_404798\MapFiles\Working_JW\Figure3-3_Conceptual_Thermal_Treatment_Area.mxd